

FD-A134 716

MICROFICHE IMAGE TRANSMISSION SYSTEM DEMONSTRATION
FIELD EVALUATION OF MICROFACSIMILE(U) NAVAL OCEAN
SYSTEMS CENTER SAN DIEGO CA D L ENDICOTT 26 MAY 83
NOSC/TR-813 F/G 9/2

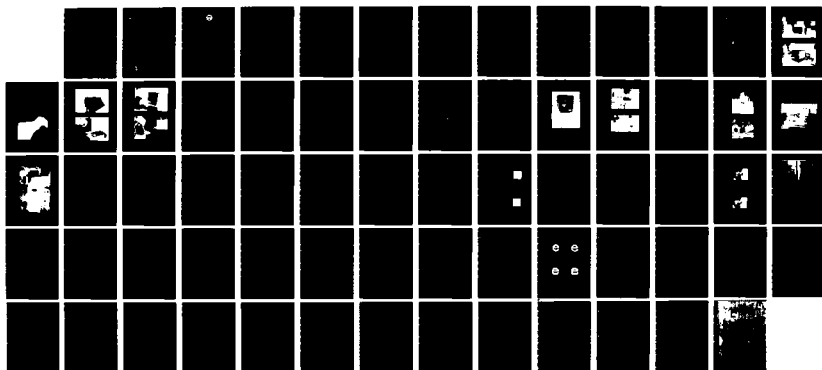
1/1

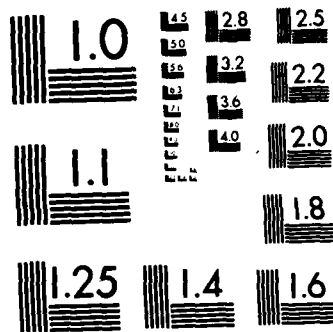
UNCLASSIFIED

NOSC/TR-813

F/G 9/2

NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

1.2

NOSC TR 813

A134716

NOSC TR 813

Technical Report 813

MICROFICHE IMAGE TRANSMISSION SYSTEM DEMONSTRATION

Field evaluation of microfacsimile

DL Endicott Jr

26 May 1983

Period of work: October 1981–October 1982

Prepared for
Naval Military Personnel Command
Code 31

Approved for public release; distribution unlimited

DTIC FILE COPY

DTIC
NOV 15 1983

A

NOSC

NAVAL OCEAN SYSTEMS CENTER
San Diego, California 92152



NAVAL OCEAN SYSTEMS CENTER, SAN DIEGO, CA 92152

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

JM PATTON, CAPT, USN
Commander

HL BLOOD
Technical Director

ADMINISTRATIVE INFORMATION

The work described was performed under program element OMN (NOSC 941-CG47) by a member of the Systems Development Branch (Code 9413) for the Naval Military Personnel Command (NMPC), Code 31-W Hopkins, program manager; M French, project officer. It represents a portion of the ongoing effort by the Advanced Systems Division, NOSC Code 941, to develop information systems and technologies appropriate to the Navy's needs. This report covers work from October 1981 to October 1982 and was approved for publication 26 May 1983.

The author acknowledges the contributions of M French, NMPC Project Office, for her diligent on-site supervision of system operations and major contributions to preparation of the system documentation and operator's manual; CWO W Chenoweth, CL Lewis, and G Howard, of the Personnel Support Detachment, Anacostia, for operating the MITS remote site facility; numerous Planning Research Corporation personnel, including W Sheppard, H Kathpal, J Skelton, J Manhire, and M Mutnick, who contributed to the design, fabrication, installation, and operation of the system; and V Hulton and J Sheposh, of the Naval Personnel Research and Development Center, for conducting and analyzing the operator and user attitude surveys.

The citation of trade names and names of manufacturers in this report is not to be construed as official Government endorsement or approval of commercial products or services referenced herein.

Released by
FA Marrone, Head
Advanced Systems Division

Under authority of
IP Lemaire, Head
Ocean Engineering Department

CONVERSION TO SI METRIC

<u>To convert from</u>	<u>to</u>	<u>Multiply by</u>
inches	mm	25.4
feet	m	$\sim 3.05 \times 10^{-1}$

WR

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NOSC Technical Report 813 (TR 813)	2. GOVT ACCESSION NO. A134716	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) MICROFICHE IMAGE TRANSMISSION SYSTEM DEMONSTRATION Field evaluation of microfacsimile		5. TYPE OF REPORT & PERIOD COVERED Evaluation October 1981–October 1982
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) DL Endicott Jr		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Ocean Systems Center San Diego CA 92152		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS PE OMN (NOSC 941-CG47)
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Military Personnel Command, Code 31 Washington DC 20370		12. REPORT DATE 26 May 1983
		13. NUMBER OF PAGES 62
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION, DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Microfiche Image Transmission System (MITS) Microfacsimile Records, remote access		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) → The MITS Demonstration was conducted for a 6-month period between 14 December 1981 and 11 June 1982. During that period, more than 1000 microfiche containing about 22 000 personnel document images were electronically transmitted between NMPC and the Personnel Support Detachment, Anacostia. These fiche represented nearly 300 active Navy personnel records. The average turnaround time was 46 minutes between making a request and receiving a facsimile record. This time included retrieval of the master microfiche, duplication, scanning, data transmission, and facsimile recording. The average scanning/transmission time was 15 minutes per record— (Continued on reverse side)		

DD FORM 1473

EDITION OF 1 NOV 65 IS OBSOLETE

S N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. Continued

slightly less than 8 seconds per document image. The facsimile documents were found to be useful to the recipients, but improvements in both the output quality and the system itself are necessary to ensure effective implementation of an operational configuration.

Session for	
US GRASS	<input checked="checked" type="checkbox"/>
US Tar	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Notification	
Distribution/	
Availability Codes	
Avail and/or	
Special	
Dist	
A-1	

DTIC
COPY
REPRODUCTION

S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

OBJECTIVES

The purpose of this report is to present the final results of the Microfiche Image Transmission System (MITS) Demonstration. This demonstration was performed to illustrate the usefulness and effectiveness of microfacsimile in fulfilling the responsibility of the Naval Military Personnel Command (NMPC) for dissemination of information contained in the Military Personnel Record System (MPRS). The demonstration consisted of design, fabrication, assembly, and installation of a prototype system, which was subsequently operated over a 6-month period in the Washington, DC area.

The intended use of the MITS Demonstration configuration was as an evaluation tool to demonstrate and test anticipated improvements in the operational efficiency of microfiche file access in a field (or remote) office environment. To be tested were three principal hypotheses:

Rapid access to a comprehensive microfiche collection improves the effectiveness of users of large data collections.

Centralized document collections are more easily, more accurately, more securely, and more cost effectively maintained than are multiple satellite collections, when the collections must serve multiple users.

Facsimile transmission of microfiche records (microfacsimile) in which off-the-shelf components are used is practical and can provide distribution of these records to remote offices more rapidly, reliably, and securely than can the conventional approaches of distribution via US Mail or courier services.

The experimental evaluation of the prototype MITS configuration had several specific objectives. These are listed as follows and are discussed in more detail in subsequent sections of this report.

Evaluate overall feasibility of remote transmission of microfiche imagery.

Verify that the specified functional and performance requirements were met.

Measure turnaround time for requests, and estimate potential system throughput.

Demonstrate the practicality of operating and maintaining devices of the complexity of the microfiche scanner and the output recorder, in a field office environment.

Measure system reliability, mean time between failures (MTBF), and mean time to repair (MTTR).

Evaluate system staffing and operator performance.

Subjectively evaluate output microfiche image quality and formats for acceptability to Navy users.

RESULTS

The MITS Demonstration was conducted for a 6-month period between 14 December 1981 and 11 June 1982. During that period, more than 1000 microfiche containing approximately 22 000 personnel document images were electronically transmitted between NMPC and the Personnel Support Detachment (PSD), Anacostia. These fiche represented nearly 300 active Navy personnel records, many of which were provided to the individuals to whom they belonged. The average turnaround time was 46 minutes between making a request and receiving a facsimile record. This time included retrieval of the master microfiche, duplication, scanning, data transmission, and facsimile recording. The average scanning/transmission time was 15 minutes per record—slightly less than 8 seconds per document image.

System performance, operator performance, and end user satisfaction were closely monitored during the 6 months of operation. Several hardware, software, and procedural enhancements were implemented and tested during this period. Thousands of personnel documents were transmitted between the NMPC facility and the remote site. These facsimile documents were found to be useful to the recipients, but improvements in both the output quality and the system itself are necessary to ensure effective implementation of an operational configuration.

RECOMMENDATIONS

NMPC

Continue to distribute microfiche personnel records to field activities and to individuals via the US Mail, employing batch handling between major Navy facilities when practical.

Respond to urgent requests by using "Express Mail" as appropriate.

Because of inherent performance limitations of the demonstration configuration, do not exercise an option to buy the prototype MITS for operational purposes.

Monitor other funded efforts at NOSC aimed at improving document legibility and image data transmission speed.

Monitor planned implementations of wideband telecommunications capability between major Navy facilities.

Evaluate applicability of partial record (eg selected-document) transmission and alternative output formats (eg video displays) for satisfying urgent record access requirements.

Update record transmission projections for the 1983-1990 period.

Continue to include record transmission considerations in future upgrades of the Military Personnel Record System (MPRS), particularly (1) bar code identification of individual fiche, (2) remote request procedures, and (3) storage, retrieval, and duplication procedures.

Continue to monitor vendor development efforts toward improving document scanning speed and legibility, high-speed image data transmission, and dry-process recording.

Monitor the success and cost effectiveness of similar systems being developed to distribute microfilm document images to high-resolution video terminals.

NOSC

Encourage standardization of image data transmission interfaces so that new devices from a variety of manufacturers can be readily integrated into future document distribution systems. The objective is to avoid development or procurement of one-of-a-kind systems, which are difficult and expensive to maintain because production quantity economies and reliability cannot be realized. Evaluate alternative design approaches for correcting deficiencies revealed by the demonstration.

Continue to monitor performance improvements and cost reductions in applicable technologies.

On a regular basis, informally advise NMPC on the commercial development status of components and systems.

Assist NMPC in procuring an operational MITS when such an installation is justified by anticipated improvements in the performance and cost effectiveness of commercially available components.

CONTENTS

BACKGROUND . . .	page 5
DESCRIPTION OF THE MITS DESIGN . . .	6
Functional overview . . .	6
System components . . .	16
EXPERIMENTAL METHODOLOGY . . .	25
RESULTS OF THE DEMONSTRATION . . .	26
Overall system functions . . .	26
System performance . . .	27
Component performance . . .	38
Personnel staffing and performance . . .	42
Acceptability to naval personnel . . .	44
SOME LESSONS LEARNED . . .	45
Gray level vs bitonal scanning . . .	45
Data entry by bar code scanning . . .	47
Reliability . . .	47
Testing and maintenance . . .	47
SUMMARY OF FINDINGS . . .	49
System performance . . .	49
Problem areas . . .	49
Overall findings . . .	50
RECOMMENDATIONS . . .	51
NMPC . . .	51
NOSC . . .	51
FUTURE PLANS . . .	53
REFERENCES . . .	54
APPENDIX A: SYSTEM ACTIVITY SUMMARY . . .	55
APPENDIX B: SYSTEM MAINTENANCE SUMMARY . . .	56
APPENDIX C: SUMMARY OF USER ACCEPTANCE RESPONSES . . .	57

BACKGROUND

The Navy's Military Personnel Records System (MPRS) is comprised of microfiche documents that correspond to personnel files for current Navy personnel. A comprehensive collection of 3.1 million silver-halide master microfiche representing 850 000 personnel is stored in semiautomated retrieval devices. Currently, access to the files is initiated by submitting a request chit. The request is filled by retrieving the master fiche, duplicating it on a diazo duplicating device, and sending the duplicate to the requestor. There are presently two categories of service: "urgent" and "routine." The urgent requests are filled in an average of 15 minutes, and routine requests are serviced overnight. If the requestor is not present to receive the duplicates at the NMPC facility in the Navy Annex of the Pentagon, the duplicate microfiche are sent via US Mail to the requestor. The primary benefit to be achieved with a microfacsimile system such as MITS is in satisfying urgent or priority requests placed from remote locations. These may be in different buildings, in the same metropolitan area, in different cities, or in different countries. The US Mail and alternative couriers would be replaced by an electronic transmission means.

During FY75 and FY76, NOSC conducted a feasibility study (ref 1), performed an options analysis, and produced a system design (ref 2) for electronically communicating the individual documents and creating facsimile microfiche at remote facilities. NOSC concluded from these studies that the three options for transmitting the microfiche records are an electronic transmission means such as MITS, air freight, and the US Mail. It was also found that the electronic method is potentially the fastest and most reliable but the most costly. It was further projected that MITS would become economically advantageous by the mid-1980s for large volume transmission requirements. Therefore, NOSC recommended that NMPC satisfy normal transmission requirements via certified mail but continue to monitor the technology and cost trends and plan for eventual conversion to a MITS technique.

NMPC continued to plan for a transition to electronic transmission. The emergence of practical, relatively low cost microimaging and facsimile transmission equipment in the marketplace prompted an investigation of techniques and applications for low-volume document transmission between NMPC and other Navy facilities to satisfy priority needs. Near-real-time access to specific files may have important advantages in personnel safety, disaster relief, casualty replacement, and security matters involving positive identification of individuals.

In FY79, NOSC reassessed the state of the art in microfacsimile technology (ref 3) and prepared a system design and performance specification for procuring a low-volume demonstration system (ref 4). Following competitive procurement, a contract was awarded to Planning Research Corporation (PRC) Image Systems Data Company for the design, fabrication, installation, and maintenance of the MITS Demonstration, with a 6-month operational period provided on a lease basis (ref 5).

DESCRIPTION OF THE MITS DESIGN

FUNCTIONAL OVERVIEW

The demonstration concept is illustrated in figure 1. The left half of the figure corresponds to the remote record user facility at the Personnel Support Detachment (PSD), Anacostia. The right portion represents the NMPC record custodian facility in the Navy Annex of the Pentagon. The geographic locations of the two sites are shown in figure 2. The MITS facilities at the remote and central sites are shown in figures 3 and 4, respectively.

The primary end users are active-duty Navy personnel who are seeking copies of their own personnel records. They are served by the remote-site operators — military and civilian employees of the PSD. The central-site operators — civilian contractor personnel — provide the interface between the MITS operation and the on-going file maintenance and fiche distribution responsibilities of NMPC.

The sequence of MITS procedures is illustrated in figure 5. A request is made from the remote site by the MITS remote-site operator. This may be done either by entering the information from a remote terminal (fig 6) or by telephoning the central-site operators. In the latter case, the central-site operator enters the request information into a local terminal. The appropriate master microfiche are retrieved from the MPRS collection and duplicate copies are prepared. MPRS "urgent" procedures are followed to ensure timely delivery of the MITS fiche. The duplicates are delivered to the MITS central-site operator (fig 7). The operator enters the request data into the MITS operator console (fig 8) and loads the fiche into the MITS scanner (fig 9). On command to transmit, the scanner automatically transports the duplicates individually to the X-Y positioning platen, scans each of the document images, and returns the fiche to an output hopper. The digitized image data are transmitted first to magnetic disks for temporary buffer storage and subsequently from the disks to the remote site via a digital microwave radio link. At the remote site, the data are input to a recorder that reproduces facsimile copies of the microfiche. The fiche are delivered to an output hopper for pickup by the remote-site operator (fig 10). Finally, the operator collects the fiche and distributes them to the requesting individuals.

The principal characteristics of the MITS design are summarized in table 1. The special features include automatically generated operator prompts, error and status messages, and audits. 'Blank image detection and image centering have been incorporated to improve the scanning speed performance, since the average fiche contains only 25 out of a possible 98 images. Thus the amount of time wasted scanning blank image locations is reduced. The input microfiche formats are shown in figures 11 and 12.

Output can be selected by the operator to be either true facsimile or image packed. The true facsimile copies are identical in content and format to the input. The packed fiche contain all the images from the original record without any of its blank spaces. The images are thereby "packed" into fewer output fiche than would otherwise be required. This serves to save processing time and film cost. Eye-readable identifier images are automatically added at the beginning of each category of images within a record.

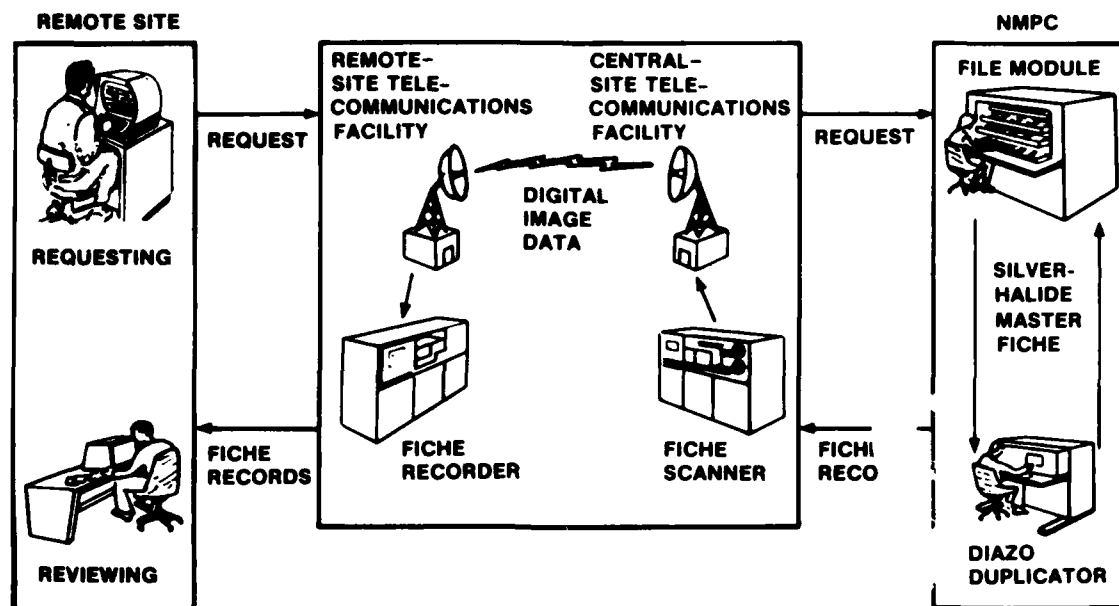


Figure 1. Demonstration concept.

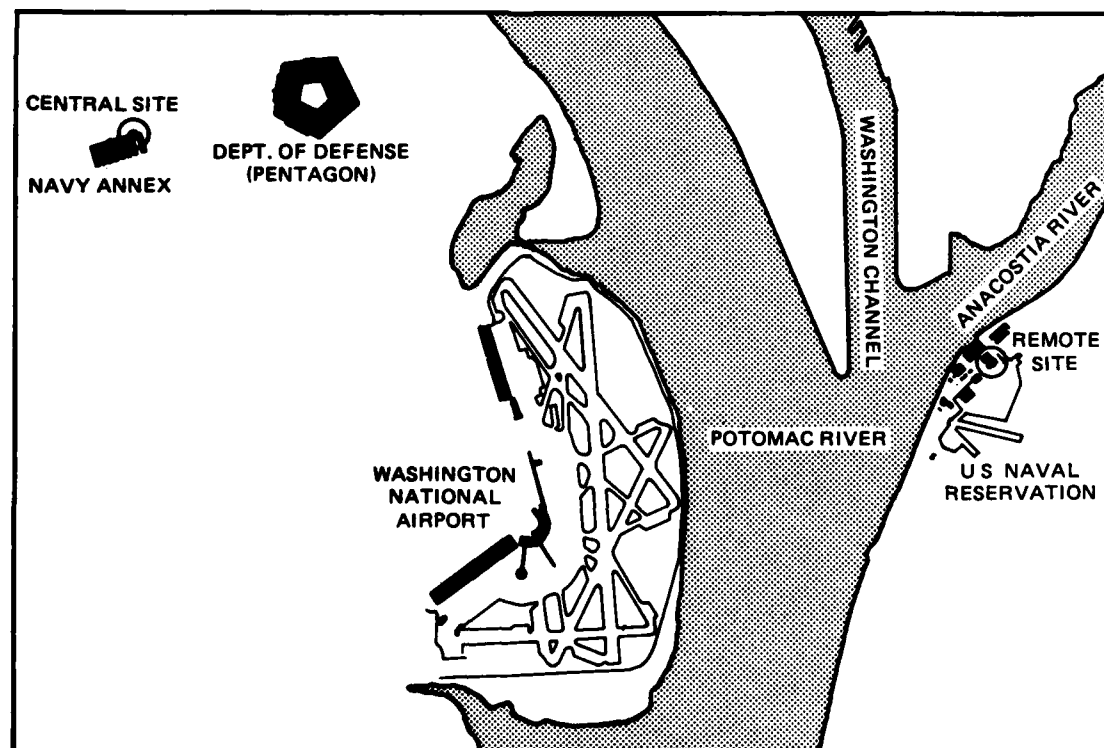


Figure 2. Location of MITS facilities.



Figure 3. Remote site at PSD, Anacostia.

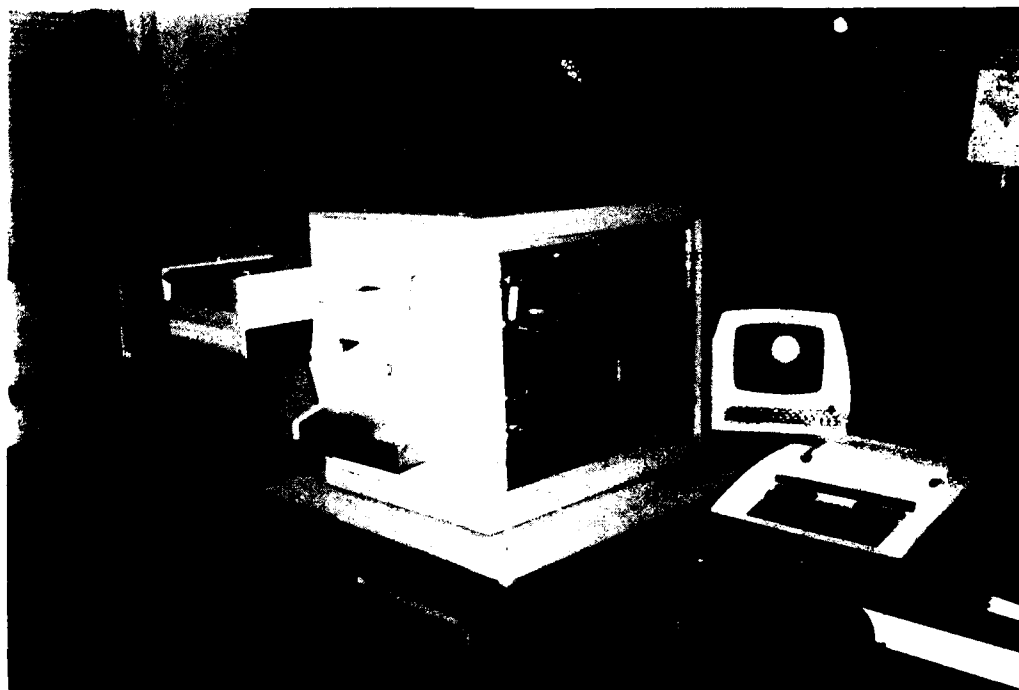


Figure 4. Central site at NMPC.

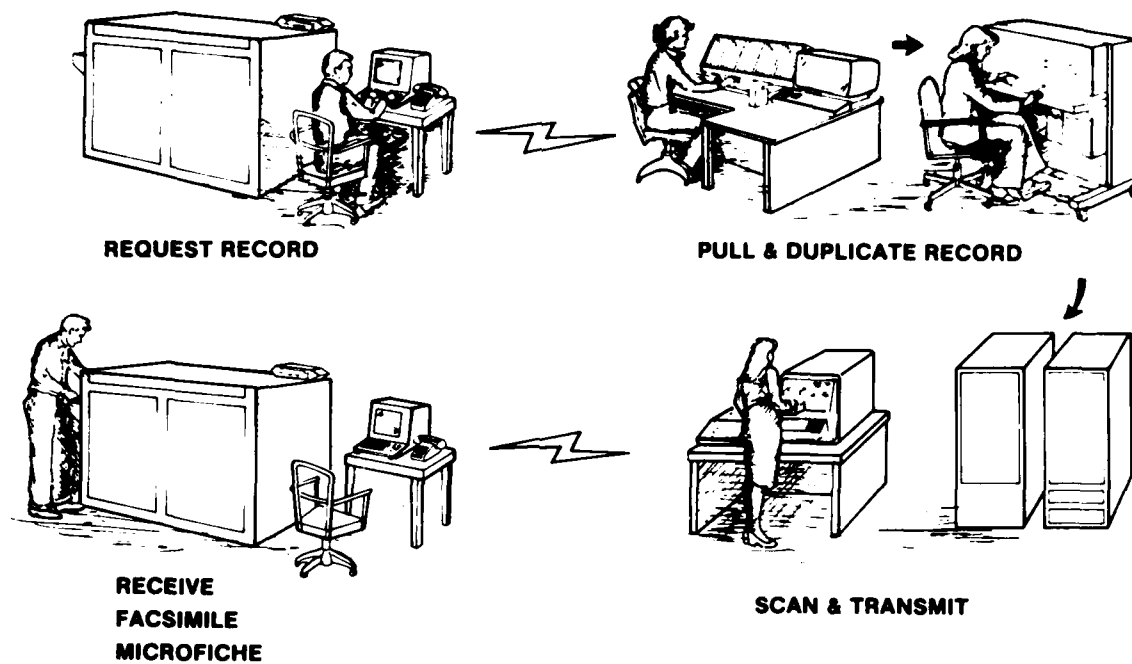


Figure 5. Sequence of procedures.



Figure 6. Entering a remote request.



Figure 7. Duplicate microfiche personnel record.



Figure 8. Central-site operator at operator console.



Figure 9. Loading microfiche into scanner.

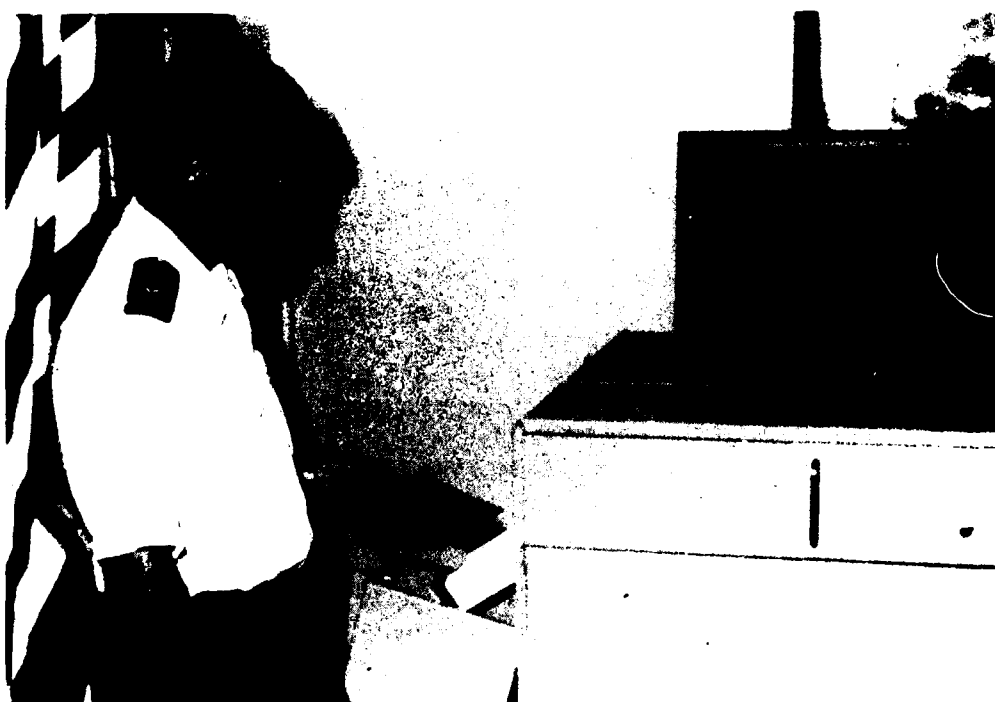


Figure 10. Receiving facsimile microfiche at the remote site.

Central location	NMPC, Navy Annex, Washington, DC
Remote location	PSD, Anacostia, Washington, DC
Microfiche	24X, 98-image, NMA Type I
Fiche images	8.5 X 11 inch, negative polarity
Record size	Officer: 117 images on 4.7 fiche Enlisted: 46 images on 3.5 fiche MITS Average: 80 images on 3.6 fiche
Scanning resolution	200 picture elements (pixels) per inch of full-size original (4800 pixels per inch on microfiche)
Output formats	True facsimile or image-packed (operator-selected)
Special features	System prompting for operator Explicit error and status messages Periodic system-generated audits Automatic blank-image detection Automatic image centering

Table 1. Summary of MITS characteristics.

[illegible]

OFFICER FICHE 1 FITNESS AND AWARDS

[illegible]

OFFICER FICHE 4 ORDERS

121 33 4444	SMITH JOHN O	2
1	EDUCATIONAL DATA	
15	QUALIFICATIONS DATA	
29	APPOINTMENTS PROMOTIONS	
57	RESERVE STATUS	
71	SERVICE DETERMINATION SEPARATION AND RETIREMENT	
85	MISCELLANEOUS	

OFFICER FICHE 2 PROFESSIONAL HISTORY

[illegible]

OFFICER FICHE 5 PRIVILEGED INFORMATION

121	33	4444	SMITH JOHN Q										3
1	SECURITY INVESTIGATIONS CLEARANCES												
	PERSONAL HISTORY STATEMENT												
29	EMERGENCY DATA												
43	RECORD CHANGES												
57	PERSONAL BACKGROUND DATA												
85	MISCELLANEOUS												

OFFICER FICHE 3 PERSONAL DATA

[illegible]

OFFICER FICHE 6 ENLISTED RECORDS

Figure 11. Microfiche personnel record formats for officers.

101 23 6655		FRANCIS PETER R		1E	
1	PROCUREMENT				
15	CLASSIFICATION AND ASSIGNMENT				
29	ADMINISTRATIVE REMARKS				
57	SEPARATION AND RETIREMENT				
85	MISCELLANEOUS				

ENLISTED FICHE 1E PROFESSIONAL SERVICE HISTORY

101 23 6655		FRANCIS PETER R		2E	
1	ENLISTED PERFORMANCE DATA				
43	TRAINING AND EDUCATION				
57	AWARDS, MEDALS AND COMMENDATIONS				
71	ADVERSE INFORMATION				

ENLISTED FICHE 2E
PERFORMANCE EVALUATION AND TRAINING DATA

101 23 6655		FRANCIS PETER R		3E	
1	RECORD OF EMERGENCY DATA BENEFICIARY SLIPS				
15	RECORD CHANGES				
29	SECURITY CLEARANCES AND INVESTIGATIONS				
43	SECURITY MISCELLANEOUS				
57	MEDICAL DATA				
71	OUT OF SERVICE INQUIRIES RESPONSE				
85	MISCELLANEOUS				

ENLISTED FICHE 3E PERSONAL DATA

Figure 12. Microfiche personnel record formats for enlisted personnel.

These are included to compensate for the output images no longer being arranged spatially into the standard fields of information.

The system is configured around a bus architecture, with the various components communicating with one another through the system bus. This is illustrated in figure 13. Portions of the bus are located at both the remote site and at NMPC. The two segments communicate with one another through the radio link via microprocessor-based communications modules. The operator console, microfiche scanner, image data buffer disks, and microfiche recorder all interface with the bus through their respective interface modules. These modules are configured around the Zilog Z-80 microprocessors, and each contains a standard "boilerplate" portion and a "personality" portion tailored to characteristics of each peripheral. This local area network design is marketed by PRC under the product name "ImageNet."

SYSTEM COMPONENTS

The various system components were either fabricated by PRC or purchased by PRC and interfaced with the ImageNet modules. Table 2 provides a summary of the major system components, which are illustrated graphically in figure 14. Brief descriptions are provided in the paragraphs that follow. More detailed information is available in reference 6.

Operator console	Teletype Corporation Model 43 teleprinter
System control processor	PRC ImageNet microprocessor (multiple Z-80 processors)
Microfiche scanner	PRC Telefiche image acquisition unit (Fairchild 1728 CCD scanner)
Image buffer disks (2)	BASF Model 6172 Winchester drives (8-inch, 24 Mbytes)
Digital radio	Farinon Corporation Model DM-18 (18-GHz carrier, 1.544 Mbits/s)
Facsimile recorder	Image Techniques, Inc graphics computer output microfiche (COM) recorder

Table 2. List of MITS components.

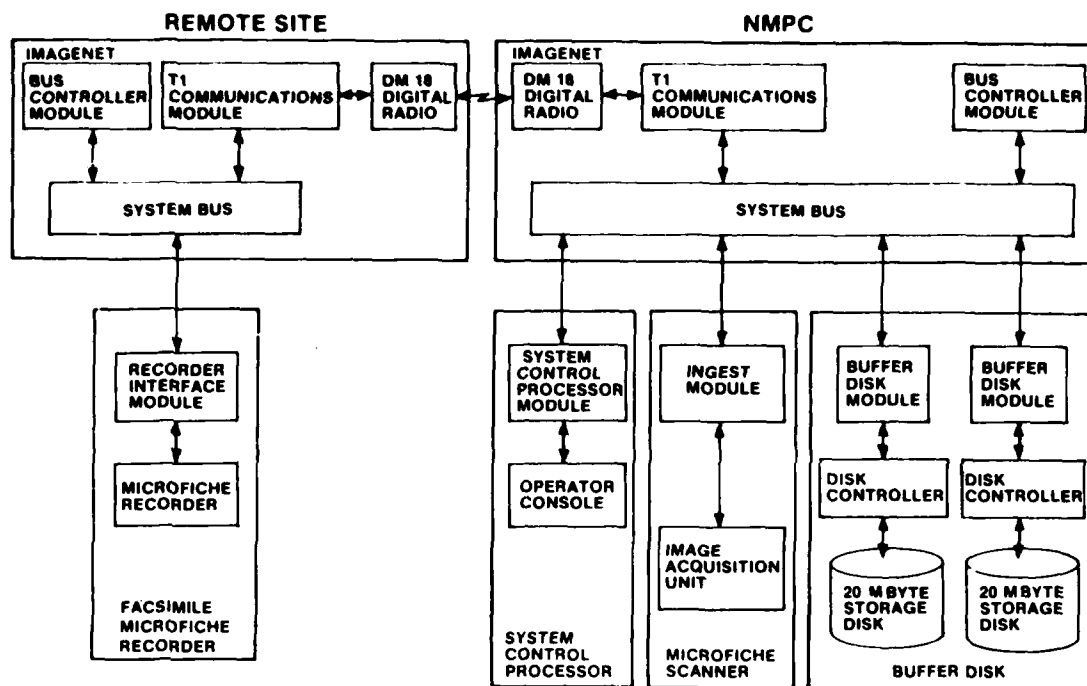


Figure 13. System architecture.

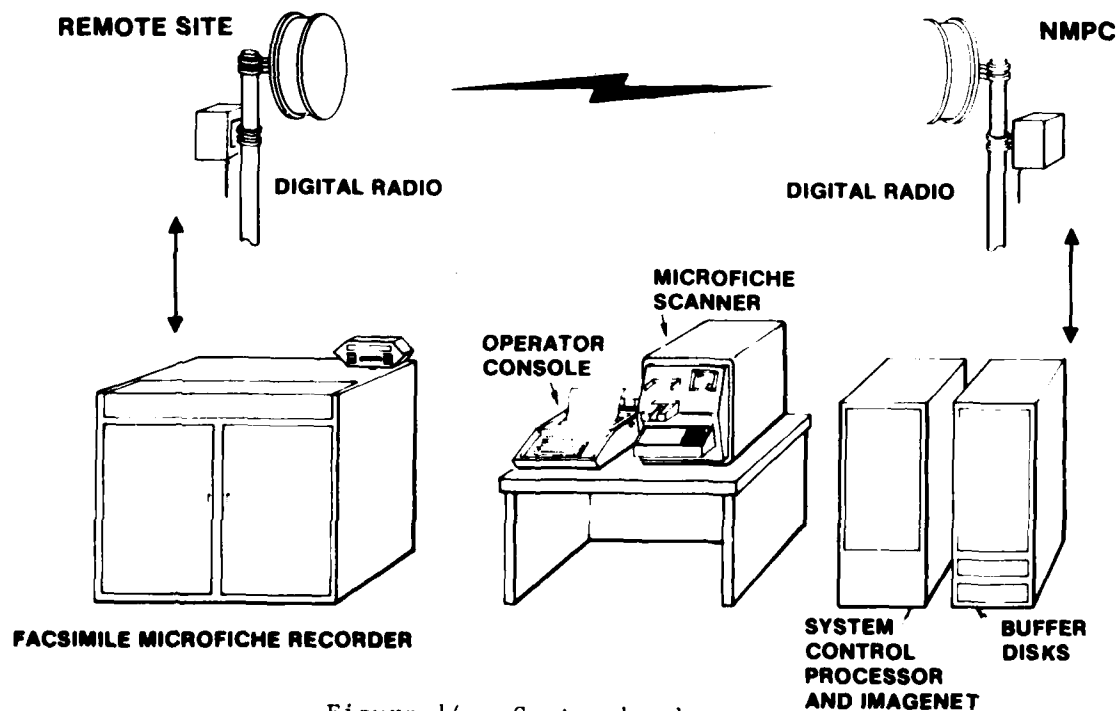


Figure 14. System hardware.

Operator Console

The operator console is a Teletype Corporation Model 43 Teleprinter. It provides the keyboard used by the central-site operator to communicate with the system controller. All operator-system dialogs are printed, since the console has no cathode-ray tube (CRT) display. The console is also used to generate the printed audit reports, which summarize system activity and document all record transmissions.

System Control Processor

The system controller, also referred to as the system control processor (SCP), is configured as an ImageNet module. It uses three Z-80 circuits for the boilerplate section and two additional Z-80 circuits for the personality input/output section. The system programs are resident as firmware rather than software, since they are stored in programmable read-only memory (PROM). In addition to coordinating overall system operation, the SCP firmware enables the following routines:

- Sign-on/sign-off
- Password security
- Maintenance of audit trail
- Execute user commands
- Edit user dialog

Microfiche Scanner

The microfiche scanner employed in MITS is referred to as the Image Acquisition Unit (IAU). It was originally developed by PRC to be part of a facsimile product known as "Telefiche." Within the IAU, a fiche transport is capable of inserting up to ten microfiche into a "fiche buffer." From this mechanical buffer, individual fiche are transported to the fiche scanning assembly, inserted between glass platens, and positioned for scanning. Scanning is performed by a Fairchild 1728-pixel charge coupled device (CCD). The major elements of the scanner can be seen in figures 15-17. To avoid scanning and transmitting blank image data, as mentioned earlier, the scanner can detect blank images by performing a prescan of each image. If two adjacent images in a given row are detected as blanks, the scanner is commanded to skip to the next row of images and to continue the prescan/scan sequence as before. The prescan also provides data to allow the scan control processor to produce image-centering instructions for the subsequent scan of the image. Both blank detection and centering are achieved through the use of correlation algorithms that operate on the prescan image data.

Image Buffer Disks

The image data are formatted and stored on two image buffer disks for transmission to the digital radio. The disks perform a data-rate buffer function and are capable of storing up to 44 scanned images each. The disks are BASF Model 6172 Winchester-type 8-inch disk drives with PRC-designed disk controllers. Each has a capacity of 24 megabytes. In addition to performing image data buffering, the disks also retain the audit trail data until printed audit reports are generated. Two disk drives are employed so that image

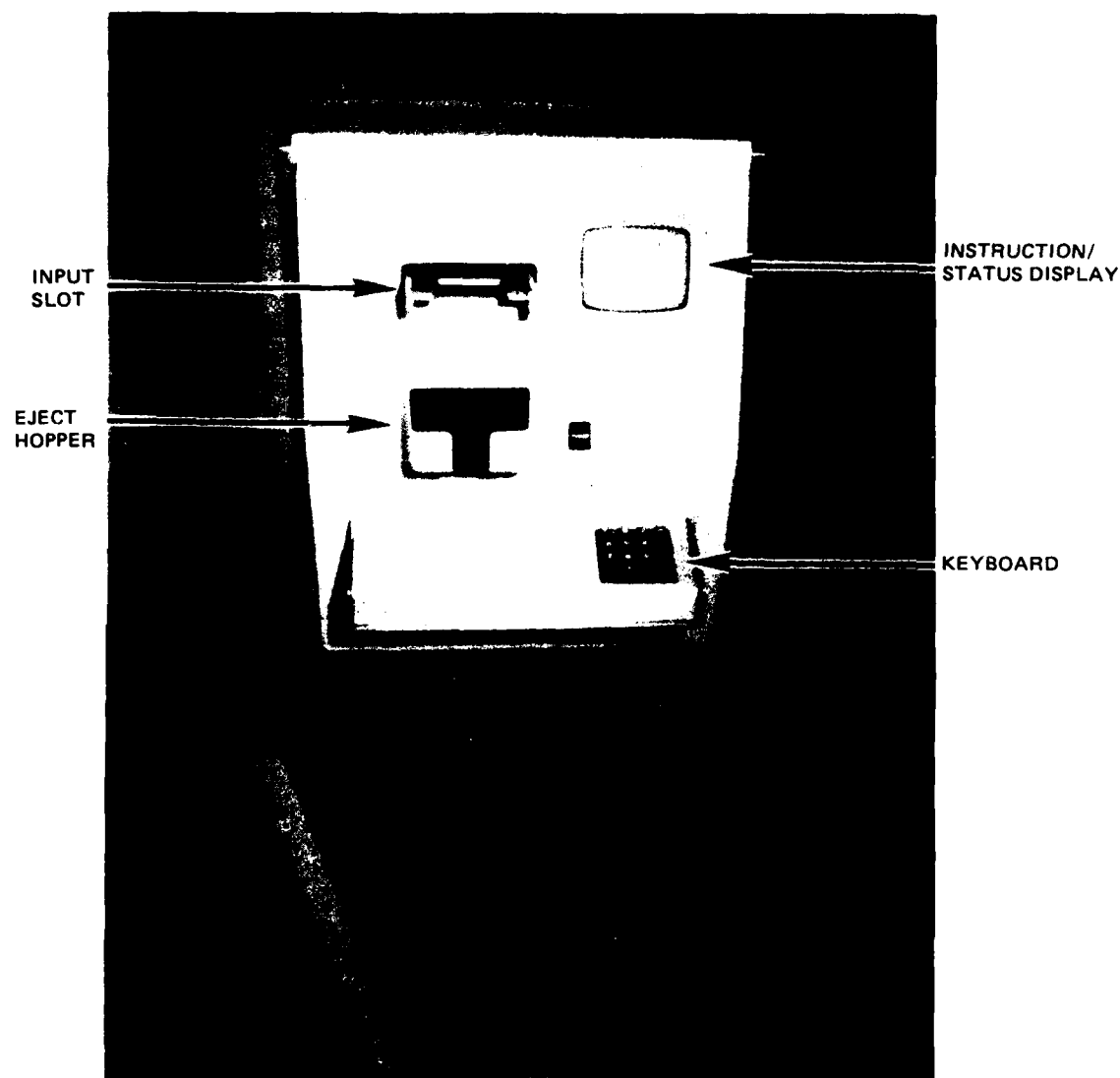


Figure 15. Front view of MITS scanner.



Figure 16. MITS microfiche transport configuration.

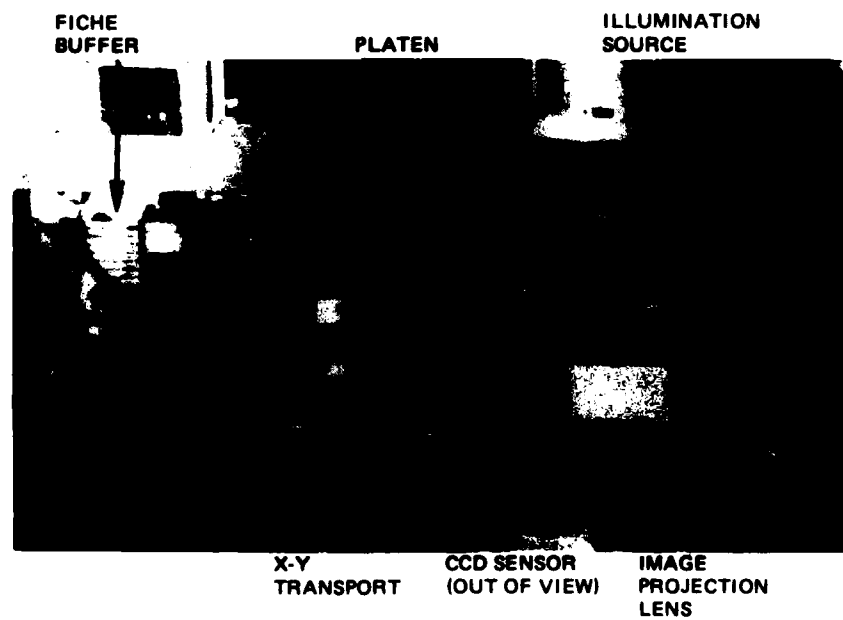


Figure 17. Side view of scanner interior.

scanning and data transmission can be performed concurrently, with one disk reading out to the radio while the other is receiving data from the scanner. This "Ping-Pong" approach allows much faster transmission than is possible with a single-disk architecture. In case of a disk failure, the second disk allows the system to continue functioning at a lower speed. The disk controllers were custom designed by PRC for compatibility with the ImageNet architecture.

Digital Radio

Transmission of the image data to the remote site is achieved with two Farinon Model DM-18 digital radios. Each is a short-haul microwave radio system operating at a nominal carrier frequency of 18 GHz and at a data rate of 1.544 Mbits per second. This is equivalent to one AT&T (Bell) T1 Dataphone digital service channel. A 4-foot-diameter antenna and an environmentally sealed transmitter/receiver housing were mounted on the rooftop at both the central and remote sites. The assembly at Anacostia is shown in figures 18 and 19. PRC also provided T1 communications modules at each termination to interface the radios to the ImageNet bus. The digital link provides a full-duplex T1 capability. System status and control data are communicated bi-directionally, whereas image data are transmitted only to the remote site. The synchronous data link control (SDLC) protocol is used for both image data and message data.

Facsimile Recorder

The facsimile microfiche recorder is a custom graphics computer output microfiche (graphics COM) recorder developed by Image Techniques, Inc (formerly Third Party Services Company) under subcontract to PRC. This unit was designed around the film transport and processor of the NCR Model 105/643 COM recorder. The MITS recorder is shown in figures 20 and 21.

A special high-resolution CRT was installed to achieve the desired MITS resolution of 200 pixels per inch of full-size document (1700 pixels per 8.5 inches of document width). Datagraphix Inc Auto1 COM film is used. This is a 105-mm-wide reversal film having a Kodak S0138 emulsion on a polyester base. It is respoled by Image Techniques into 100-foot-capacity cartridges that are compatible with the NCR transport. The film processor uses NCR standard IR-15 reversal chemistry packs consisting of first developer, stop bath, bleach, clearing solution, second developer, final wash, and drying agent.

The recorder's microprocessor controller includes a bus interface module, which receives the positioning instructions and the image data from the T1 communications link and directs it to the controller and CRT, respectively. Figure 22 illustrates this architecture. The film is positioned over the CRT screen at the proper grid location, then exposed to the displayed image on a line-by-line basis. After exposure of all the images on a given fiche, the recorder cuts the film and directs it to the processor and subsequently to an output hopper. Header information and eye-readable category identifiers are created on the CRT face by means of a character generator resident within the recorder. The character algorithms are stored in the recorder's memory so that only identifying codes are transmitted over the radio link.

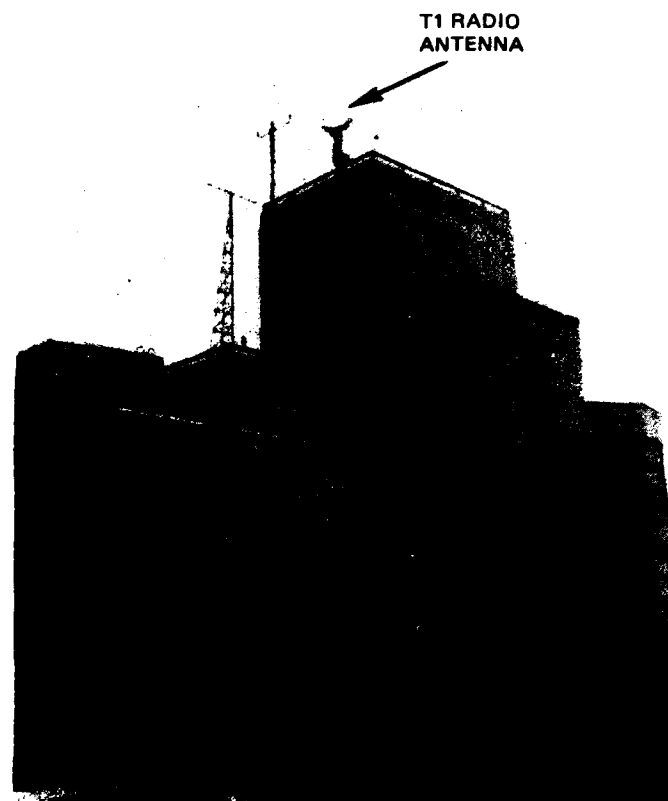


Figure 18. Location of T1 radio antenna at PSD, Anacostia.

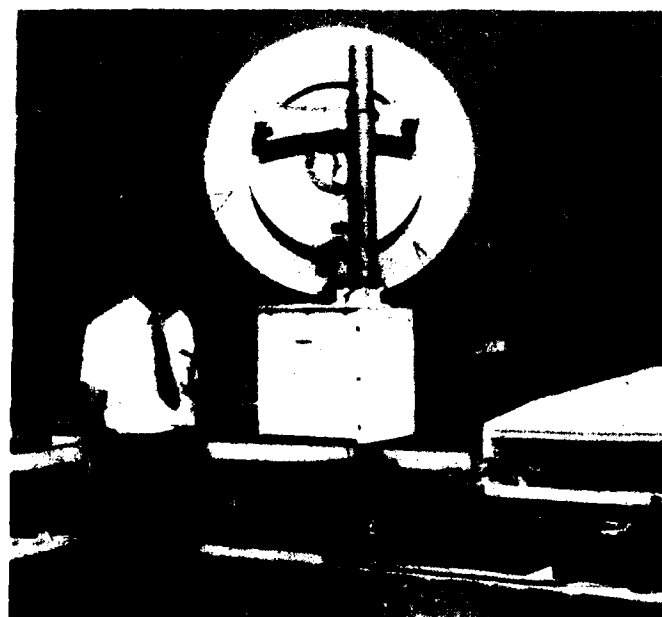


Figure 19. T1 radio closeup view.

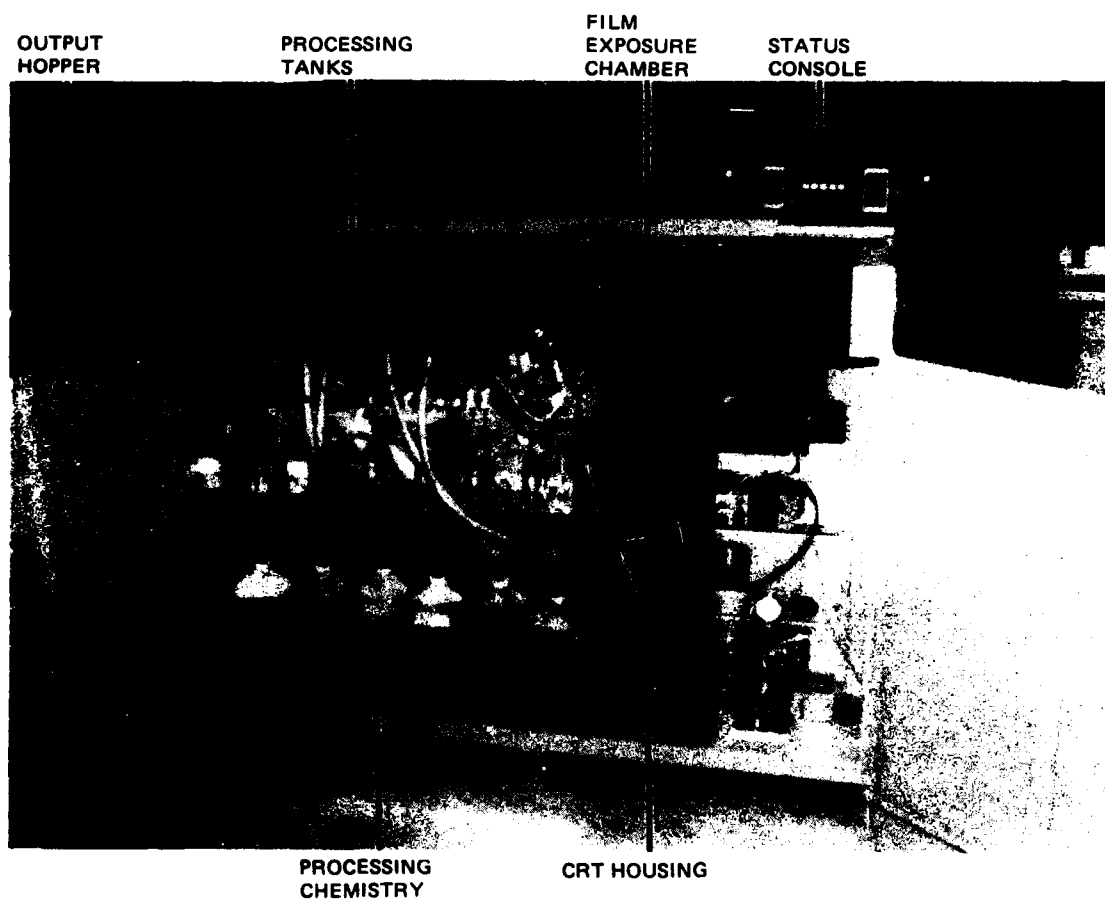


Figure 20. COM recorder.

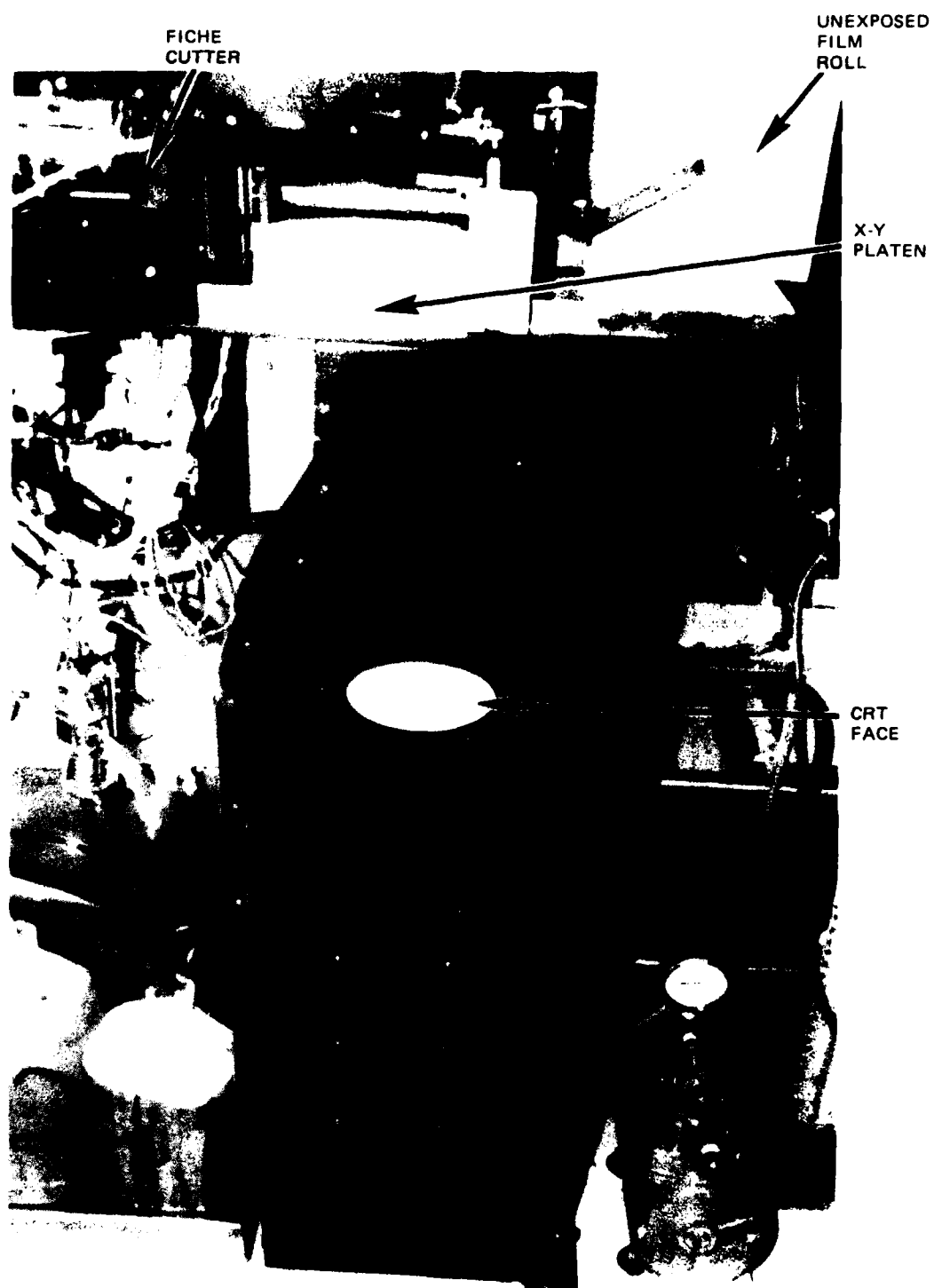


Figure 21. COM recorder detail view.

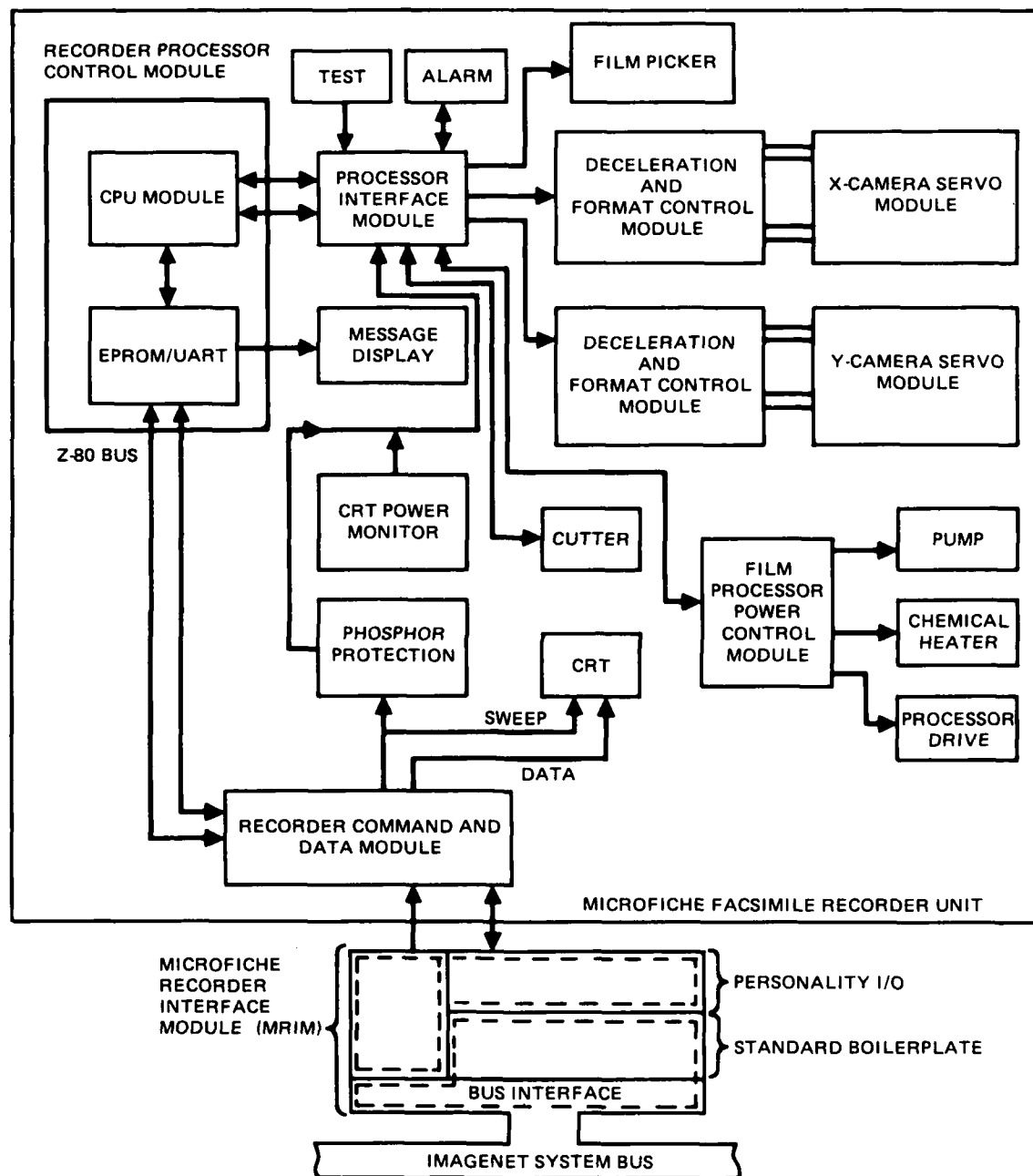


Figure 22. Microfiche facsimile recorder architecture.

EXPERIMENTAL METHODOLOGY

The MITS Demonstration was performed to evaluate the benefits of microfiche facsimile in a field office environment. To that end, actual active duty personnel records were transmitted to PSD, Anacostia, and released to the individual officers and enlisted personnel. Of necessity, this pilot demonstration was not of a fully operational nature. Navy personnel were encouraged to request their records when they visited the Anacostia office, but alternative methods were certainly available to them. For example, they could travel the 5-mile distance to the Navy Annex and request duplicate records in person. Request activity was limited to a nominal five records per day to minimize the impact of MITS on the normal full-time responsibilities of the MITS operators.

The experimental plan had seven principal objectives:

Evaluate overall feasibility of remote transmission of microfiche imagery.

Verify that the specified MITS functional and performance requirements were met.

Measure average request turnaround time and estimate potential system throughput.

Evaluate the practicality of operating and maintaining devices of the complexity of the microfiche scanner and the facsimile recorder in a field office.

Measure system reliability, including mean time between failures (MTBF) and mean time to repair (MTTR).

Determine the system requirements for operator staffing and skill levels.

Subjectively evaluate the quality and legibility of facsimile documents and validate their acceptance by the requestors.

The experimental objectives were met in a variety of ways. System performance and reliability were determined by reviewing the system audit log, the remote site log, and the maintenance log. Operator performance and attitudes were monitored by conducting initial and follow-up interviews. Acceptance of the records was measured by examining the questionnaires filled in by the requestors. Document legibility was evaluated by polling test subjects on a panel. Finally, overall system feasibility and practicality were analyzed by interviewing the MITS project personnel (system designers), the operators (system users), and NMPC and PSD management (system "owners"). The interviews, questionnaires, and panel evaluations were administered by the Navy Personnel Research and Development Center (NPRDC).

RESULTS OF THE DEMONSTRATION

OVERALL SYSTEM FUNCTIONS

Procedures

The system functions include facsimile transmission (scanning, telecommunications, recording), restricting access, maintaining audit trails, monitoring system status, orderly failure detection and recovery, and troubleshooting. No special test procedures were employed for evaluating these functions. Audit reports, the remote site log, and the maintenance log were reviewed to assess system activity. Subjective observations by the system operators, supervisors, and maintenance personnel were solicited through personal interviews conducted by NPRDC.

Results

Each of the system functions was successfully demonstrated during the 6-month demonstration period. During this period, 1015 fiche were successfully transmitted between NMPC and PSD, Anacostia. These contained approximately 22 500 document images. Table 3 summarizes the transmission activity. A more detailed summary is provided in appendix A.

Operational period	14 Dec 81 - 10 Jun 82
Transmission activity	
Number of records	282
Number of fiche	1015
Number of images	22 500 (approx)
Transmission time	
Average per image	7.8 seconds
Average per record	13 minutes (includes film processing)
Turnaround time	46 minutes

Table 3. MITS transmission activity.

Access was restricted through the use of password-protected sign-on procedures. There was no rigorous effort to change the password frequently or to enforce any exceptional security measures. During the final acceptance tests, numerous attempts to access the system without knowledge of the password were unsuccessful.

Audit reports were routinely produced upon command from the system operator to the system controller. These were usually produced at the end of every week. Unfortunately, the controller software had a bug which allowed a

knowledgeable operator to erase the audit data file whether or not the latest audit report had been printed. Loss of audit data occurred at least once when the PRC maintenance person accidentally erased this file. For this reason, the system activity summarized in table 3 is a compilation of audit data and remote-site log entries, and the total image count is an estimate.

System status monitoring was partially successful. Failures of only a limited variety were anticipated by the system and component designers, so the controller was programmed to detect and announce only a few. A thorough status check was made during morning start-up or operator sign-on. The system reliably reported on the condition of the principal components, and a status report was automatically printed indicating whether or not each component was "ready." Unfortunately certain failure modes resulted in no message of any kind. Occasionally image transmission was interrupted while the operators were unaware of any problem. Degradation of the telecommunications channel was the principal cause.

Failure detect and recovery procedures were very limited in scope and effectiveness. Toward the end of the demonstration, new kinds of failures were occurring regularly, especially in the output recorder. Since there was no remote system controller, failures at the remote site were often difficult to detect from the operator console at the central site. Major component failures were frequently detected, however, and they were announced properly by both an alarm bell and a message printed at the console. In all such cases, the operator was instructed to contact the system maintenance person for diagnosis and repair. The scanner, digital radio, and recorder all possessed error-detection capabilities, but many of the error messages were not communicated to the system controller. Even at the device level, the error-detection features were not comprehensive.

Troubleshooting was exclusively the responsibility of PRC's maintenance personnel. This assignment was due to the complexity of some of the failures, the cryptic error messages, and a regular requirement to interact with the system controller from a CRT maintenance terminal by using binary coded instructions. The operators did assist in troubleshooting, primarily from telephoned instructions, since the two sites were 5 miles apart. The system designers were frequently required to isolate the causes of failures, adding significantly to the repair times.

SYSTEM PERFORMANCE

This section describes how well the MITS performance specification specifications were met. The performance criteria to be discussed are the system throughput, output microfiche quality, system reliability, and system operating and maintenance.

System Throughput

Although there was no formal attempt to determine how many records could be transmitted in a day, throughput can be computed on the basis of scanning time and turnaround time. The facsimile recording time was measured by using

system clock entries in the audit reports. Overall turnaround time was calculated from entries in the remote-site log for the time of request and the time of receipt of the record.

System throughput is a direct function of the turnaround time. Figure 23 is a timing diagram showing the various elements that constitute a record transmission. It can be seen that the total turnaround time represents the interval between a request from the remote site and delivery of the last fiche to the output hopper. On the basis of the remote site logbook entries, the average turnaround time during the demonstration was 46 minutes. The time required for the MPRS to retrieve and duplicate the requested fiche was typically 20 minutes. The transmission time for the average record of 80 images and 3.6 fiche was 7.8 seconds per image or 10.5 minutes per record. Film processing and drying of the last fiche in a record added 2.5 minutes. Therefore, the interval from a fiche retrieval at NMPC until the complete record was available for distribution at PSD was about 33 minutes. The additional 13 minutes represented in the 46-minute turnaround is attributable to request time on the telephone, request data entry into the MPRS terminal, and data entry and fiche loading procedures performed at the MITS console and scanner. In summary, the average fiche transmission times (in minutes) were as follows:

Retrieval and duplication	20
Scanning and transmission	10.5
Film processing and drying	2.5
Data entry, loading, other	13
Total	46

The scanning time was measured with a stop watch on several occasions. It was recorded (in seconds) as follows, by element:

Prescan	1.0
Platen reposition	0.3
Scanning	3.7
System overhead	0.6
Blank detect, header, other	2.2
Total	7.8

The 0.6-second overhead represents a time interval during which the system alternatively directed each of the two disk drives to receive scan data while the other was transmitting to the digital radio in a "Ping-Pong" approach. Included in the 7.8-second average per image cited above is the prescan time for blank image detection (two consecutive blanks for each row). Also included is an overhead time for recorder printing of the header information on each output fiche. These "other" time elements were determined by subtracting the timed scanner performance of 5.6 seconds from the 7.8-second average transmission time per image. Collectively, these factors added to the average scanning time of 7.8 seconds per image. Note that the 1.544-Mbps communication link is capable of transmitting one of the 3.75-Mbit images in under 3 seconds.

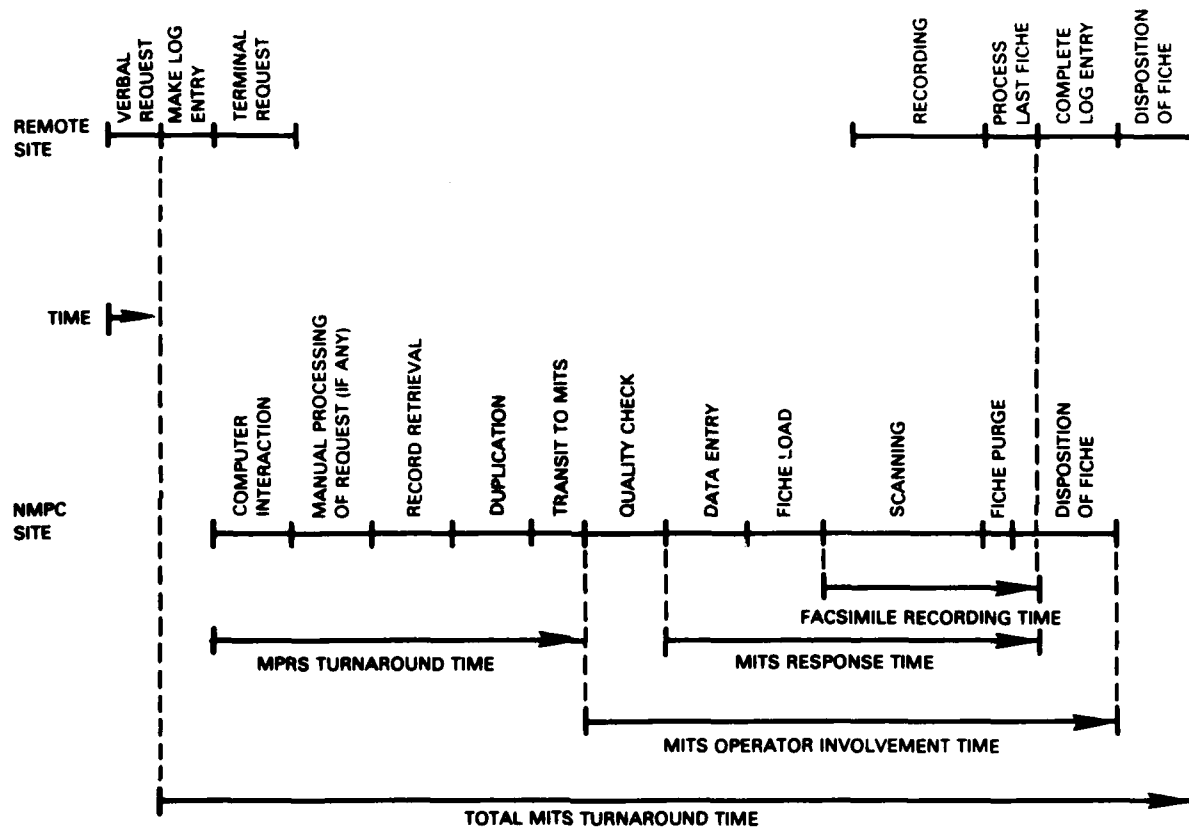


Figure 23. MITS timing diagram.

There are at least two ways to compute system throughput. If each request is handled individually, the minimum throughput is equal to the length of day divided by the turnaround time per request. For an 8-hour day and a 46-minute turnaround, throughput equals 10 requests per day. However, records can be retrieved and processed while another record is being transmitted. In fact, these activities can be performed continuously, and the records can be batched for loading into the scanner. If such a batch is prepared in advance for the start of each MITS work day and the scanner and recorder are operated continuously during that day, the MPRS retrieval time is no longer a throughput factor. In this case, the total MITS handling time approaches 10.5 minutes per record. Throughput can then be computed as $8 \text{ hours} / 10.5 \text{ minutes} = 45 \text{ records/day}$. To summarize, the computed MITS demonstration throughput based on the 80-image 3.6-fiche average record is as follows:

Individual requests	10 records/day, minimum
Batch requests	45 records/day, maximum

Again, there was no attempt to demonstrate these throughput capabilities. There may be a number of operational and procedural difficulties associated with the batch processing of so many records. Possible limitations of the MITS prototype (but not the technology) include a 10-fiche input buffer, limited memory capacity in the microprocessor controller, and extensive key-stroking of request data for each record.

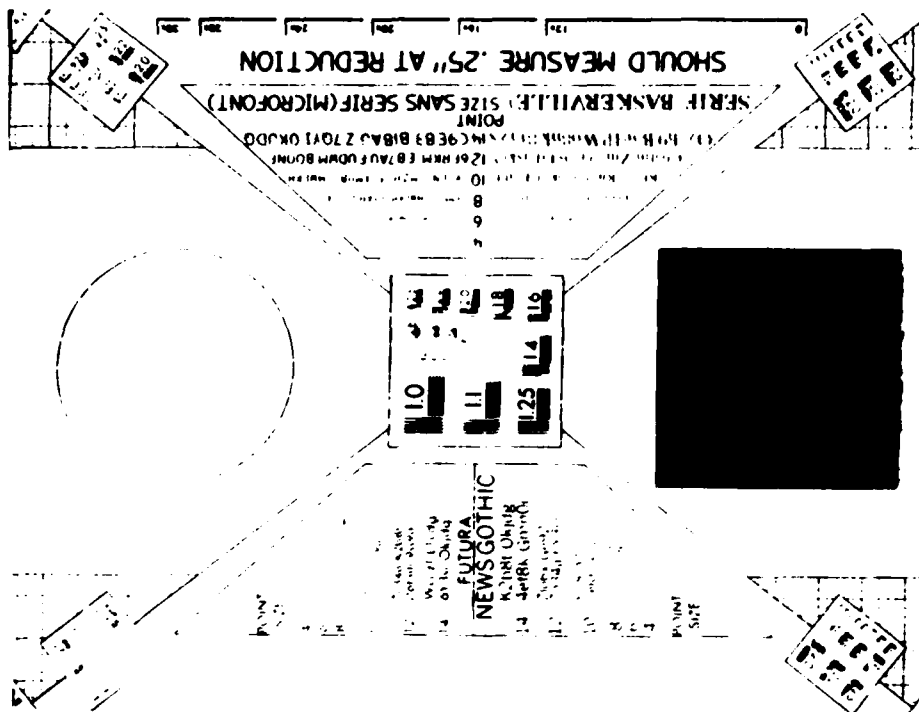
Output Microfiche Quality

Output image quality is probably the most important consideration for ensuring user acceptance of a facsimile transmission system. Unless documents can be legibly reproduced in virtually all cases, users will become discouraged quickly with the system's capabilities and probably will use it less. The primary attributes of an image that contribute to quality are resolution, linearity, density, physical appearance, and legibility. The quality of the MITS output microfiche is described next in terms of these factors.

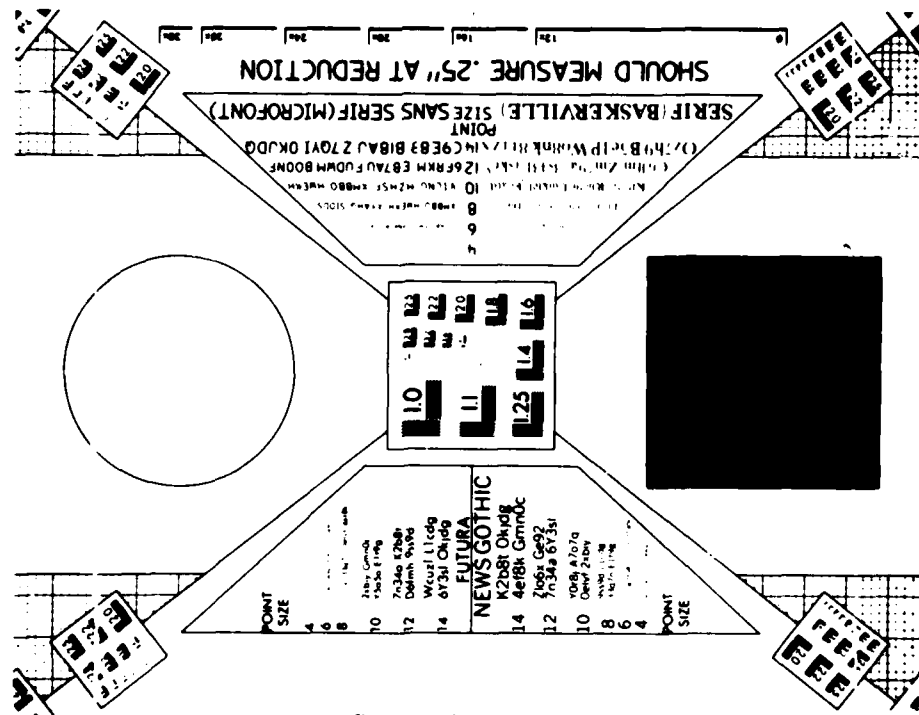
Resolution. A previous study conducted as part of the MITS development effort indicates that a resolution of 180 picture elements per inch (of full size document) is required to resolve out-of-context 6-point typewritten characters — a print size common on Navy personnel forms (ref 7). Typical 6-point characters are between 0.031 and 0.047 inch in height.

The prototype MITS has a scanning resolution of 200 picture elements per inch both horizontally and vertically. Yielding at least 6 scan lines per lower-case 6-point character, this resolution was selected by the PRC designers to meet MITS performance requirements and to be compatible with the high-quality facsimile standard of 200 lines per inch.

To verify MITS resolution capability, a resolution-target microfiche was prepared from the Photographic Sciences Corporation MT-2 test chart. The target images contain National Bureau of Standards (NBS) microcopy resolution test charts in the center and each corner (fig 24). During acceptance testing, the test fiche was scanned and transmitted and a facsimile copy was produced at the remote site. Images from each row in various columns were subsequently viewed with a microscope, and the resolvable targets were recorded.



Facsimile Output



Dialo Input

Figure 24. MITS resolution target.

Reference 7 indicates that the "Kell" factor should be used when comparing scanning resolution with photographic resolution. Typically assigned a value of 0.7, this factor multiplied by 200 pixels per inch translates this scanning resolution into an expected photographic resolution of 2.7 line pairs per millimeter (lpm) as follows:

$$0.7 \times 200 \text{ pixels/inch} \times (1 \text{ inch}/25.4 \text{ mm}) \times (1 \text{ line pair}/2 \text{ pixels}) \\ = 2.7 \text{ lpm}$$

Nominal MITS resolution values were found to be 2.8 lpm, with a range from 2.0 to 3.6 lpm. The low values were for the orthogonally oriented target at the center of each image. These measurements confirmed the resolution capability of the system. However, it was discovered that textual legibility and appearance are improved if the video tracking circuitry of PRC's image processor is slightly detuned. In this condition, the resolvable targets were in the range of 1.6 to 2.8 lpm, with values consistently lower than the 2.8-lpm normal resolution mentioned above. The detailed test procedures appear in reference 8.

Linearity and Density. Image linearity and uniformity of density indicate the degree of image distortion and the uniformity of film exposure and processing. They were measured during the acceptance tests by using other targets on the test microfiche. Geometric linearity was measured by using microfiche images of quadrille paper. Linearity in both the horizontal and vertical directions was ± 1.2 percent. Image density was measured by placing the density circles from the output resolution targets in a microdensitometer. Typical values were 2.6 for the dark area and 0.7 for the light area. Density values over the entire fiche varied by ± 6 percent. These values represent measurements made on one output microfiche created during factory acceptance and another produced during final acceptance. As discussed under Component Performance, density values varied considerably more than this during the actual demonstration because of difficulties with the film developer.

Image Quality. Although resolution, linearity, and density affect user acceptance of facsimile output, legibility and appearance are of primary importance. Whereas the previously discussed characteristics can be quantitatively measured, image quality must be subjectively evaluated. For the demonstration, this evaluation was done by visual inspection of selected images. A noticeable degradation in quality was observed between the diazo duplicate images and the facsimile images. Figure 25 compares typical input and output from the demonstration.

The MITS output is characterized by higher contrast but suffers from the breakup of character edges, filling in of some characters (eg letters e and o), and a variety of cosmetic blemishes. Of particular concern is the impact these collective faults have on the legibility of typewritten characters that are not decipherable from their context alone. Examples include numbers and letters that are not part of words. Out-of-context characters are prevalent on personnel forms and often constitute information of primary interest. As will be discussed in the next section, these effects appear to have a direct impact on document legibility.

[illegible][illegible]

Facsimile Output

Díaz Input

Figure 25. Comparison of MITS input and output.

Legibility. Legibility can be defined broadly as the capability of being read or deciphered. For the MITS design, output legibility was to be maintained through use of bitonal adaptive thresholding. The threshold circuitry was tuned for reproduction of text rather than of resolution targets. Accurate reproducibility of photographs was not considered to be a performance objective, and, in fact, bitonal processing renders these as high-contrast images with minimal detail (fig 26).

Because of the complexity of evaluating the many factors influencing document legibility and given that the MPRS record collection represents a diversity of document types and quality, a decision was made to evaluate output legibility subjectively, by using a controlled group of users. Such an analysis was performed by the Naval Personnel Research and Development Center during the demonstration period. In a panel of 13 military and civilian Navy personnel, each was asked to evaluate 80 randomly selected images produced by MITS. Eight of the group viewed both the input and output versions of each image in a side-by-side comparison. Each of the eight was asked to select the preferred ones and to record the choices on a prepared response sheet. These panel members were not influenced by an interviewer or proctor. The diazo input version was selected as superior in 88 percent of the cases. The other five members of the group were allowed to view only the facsimile output versions of the 80 documents. They were asked to characterize each document as "readable," "somewhat readable," or "not at all readable," again recording their reactions on a response sheet. The results were as follows:

Readable	35 percent
Somewhat readable	40 percent
Not readable	26 percent

Although the sample of test subjects was small, the results were judged to be statistically significant (ref 9).

Physical Appearance. Several cosmetic blemishes in the output fiche were observed. Although these do not necessarily affect legibility, they may be found objectionable by some users and may indirectly impact user acceptance. These flaws included background speckle, exaggerated dust and scratch marks, and large areas of horizontal streaking. This last behavior, shown in figure 27, is probably a function of how sensitively the adaptive thresholding circuitry is tuned to detect faint characters. If the threshold logic is set for very faint (low density) or very thin (high spatial frequency) characters, it is probably overly sensitive to input film flaws such as dust and scratches. In the example of figure 27, the normally uniform background has large areas improperly recorded as streaks. Note, however, that when typewritten characters are present, their features are detected and legibly reproduced.

Some of the fiche left in the output hopper of the recorder became bonded to one another. This was the result of incomplete drying prior to ejection of the film from the processing tank. Frequently they could not be separated without tearing the fiche substrate. When such bonding occurred, retransmission was required. Many of the fiche also showed fingerprint markings.



Díazo Input



Facsimile Output

Figure 26. Bitonal reproduction of photographs.

002 07

Know Th, that repelling special trust and confidence in the Patriotic, Water,
Fidelity and abilities of
by and with the advice and consent of the Senate, appoint
HIM AM

ENSLIGN
UNITED STATES NAVY

to rank as such from the TWENTIETH day of DECEMBER nineteen
hundred and EIGHTY

THIS IS A BELIEVED DOCUMENT FOR FILE
AND RECORD PURPOSES OF THE ARMED
FORCES TYPE COMMISSION ISSUED TO THE
ABOVE NAMED OFFICER.

Done at the City of Washington, this
TWENTY-SEVENTH day of OCTOBER
in the year of our Lord one thousand nine hundred and
Independence of the United States of America the EIGHTY
EFFECTIVE: DATE ACCEPTED TWO HUNDRED AND FIFTH
By the President

LANDO W. ZECH, JR

EDWARD BURNHAM
VICE ADMIRAL, U. S. NAVY
CHIEF OF NAVAL PERSONNEL
SECRETARY OF THE NAVY

FILE NO.

CUJ1 PAGE (JULY COPY)

Diazo Input

002 17

Know Th, that repelling special trust and confidence in the Patriotic, Water,
Fidelity and abilities of
by and with the advice and consent of the Senate, appoint
HIM AM

ENSLIGN
UNITED STATES NAVY

to rank as such from the TWENTIETH day of DECEMBER nineteen
hundred and EIGHTY

THIS IS A BELIEVED DOCUMENT FOR FILE
AND RECORD PURPOSES OF THE ARMED
FORCES TYPE COMMISSION ISSUED TO THE
ABOVE NAMED OFFICER.

Done at the City of Washington, this
TWENTY-SEVENTH day of OCTOBER
in the year of our Lord one thousand nine hundred and
Independence of the United States of America the EIGHTY
EFFECTIVE: DATE ACCEPTED TWO HUNDRED AND FIFTH
By the President

LANDO W. ZECH, JR

EDWARD BURNHAM
VICE ADMIRAL, U. S. NAVY
CHIEF OF NAVAL PERSONNEL
SECRETARY OF THE NAVY

FILE NO.

CUJ1 PAGE (JULY COPY)

Facsimile Output

Figure 27. Cosmetic flaws in MITS output.

System Reliability

System reliability was evaluated both qualitatively and quantitatively. Because fiche transmission activity was limited, peak demand response was not measured. A complete maintenance log was maintained by PRC maintenance personnel. All system failures were recorded along with the time of the failure, a description of the failure symptoms, the corrective action taken, and the time of system return to operation. This information was analyzed in conjunction with the usage activity to determine the mean time between failures (MTBF) and the mean time to repair (MTTR).

The period of 22 March to 21 April 1982 was used as the basis for computing MTBF and MTTR. By March, the original magnetic buffer disks had been replaced by the significantly more reliable Winchester drives. There was also performed, prior to March, a significant amount of system debugging including shipment of the digital radio to California for a several-week diagnosis of a frequency-drift problem. Following the March-April evaluation period, frequency drift again occurred, resulting in numerous transmission delays and time-out failures. This problem was left uncorrected because of the high cost of purchasing or renting a frequency calibration device and the limited amount of time remaining for the demonstration.

An itemized summary of failure and repair activity for the 30-day evaluation period is presented in appendix B. This information is extracted from the maintenance log and the remote-site log, both of which cover the entire demonstration period. Many of the failures were related to mechanical part failures in the facsimile recorder. Intermittent failures occurred in the x-y film positioner, the fiche cutter, film rollers, pumps and pump motors, and film drive gears.

The MTBF was computed as the difference between operating and repair time divided by the number of major failures. There were 19 operating days of 8 hours each and 16 major failures that required a total of 73 hours of repair time. Thus

$$\text{MTBF} = [(19 \times 8) - 73] / 16 = 5 \text{ hours.}$$

The MTTR was computed by dividing the total repair time by the number of failures. Thus

$$\text{MTTR} = 73 / 16 = 4.5 \text{ hours.}$$

The computed values of MTBF and MTTR indicate that the system was available for record transmission approximately 50 percent of the time.

System Operation and Maintenance

It was necessary to show that electro-optical devices of the complexity of the microfiche scanner and the output recorder can be operated and maintained reliably in field office environments. The constraints of limited office space, marginal environmental control (temperature, humidity, air quality, electrical power stability) and inadequately trained system operators perhaps lacking the special skills required to operate computer peripheral devices or microfiche equipment are likely to impact system reliability. Specialized

skills of this type normally would not be included in the job description for a PSD office supervisor, for example, who is primarily a personnel specialist. Furthermore, the COM recorder requires a great deal of routine preventive maintenance and replenishment of supplies, such as replacement of film and processing chemicals. In addition, scanning requires a lengthy interactive dialog between the operator and the system controller via the keyboard unit.

MITTS data entry procedures are functionally adequate, but several operational inefficiencies were noted. Because there was no direct communication link between the MPRS process controller and the MITTS controller, request data (including name, Social Security number, and fiche category identification) had to be entered manually for a second time at the operator console prior to loading the fiche into the scanner.

The necessity of making requests by telephone and having someone key in the request data is awkward, since the PSD operator has to establish personal contact with the NMPC operator. "Telephone tag" was not cited by the operators as a major problem, but some time was undoubtedly lost by the attempt to reach someone who could enter the request data. Establishment of a direct connection between the remote site and the MPRS via a remote terminal connection, as originally planned, would speed request entry and probably reduce the number of staff required at the NMPC facility. Additional duties and familiarity with the MPRS data base would be required of the remote-site operator, however.

Preventive maintenance procedures were generally restricted to the remote site. The remote-site operators had to replace the six bottles of film processing chemistry and thoroughly clean the processing tanks at least once every week. This can be a messy job, requiring special care to protect skin and clothing from stains. Chemistry changes took between 30 minutes and an hour to complete. Film loading was a more straightforward standard procedure at which the operators became quite proficient. Facilities were necessary for cold storage of the film and room-temperature storage of the chemistry.

The corrective maintenance procedures were not well established prior to the demonstration. There was only a limited system-exercising period prior to installation. Most of the failures observed during the demonstration were first-time occurrences requiring a considerable amount of "seat of the pants" diagnosis. There was no prepared maintenance manual, and the system designers were frequently called in for consultation. The maintenance personnel were conscientious in responding to failures quickly and with enthusiasm, in spite of frequent shuttling between the two sites to isolate failure symptoms.

COMPONENT PERFORMANCE

This section addresses how well the system components met the functional and performance requirements of the MITTS Technical Specification (ref 4).

System Controller

As "traffic director" for the system, the controller functions are as follows:

Control or direct the scanning process.

Accept system operator commands and data.

Control or direct the communications facilities.

Detect subsystem failures and respond through prearranged strategies.

Provide feedback messages to the operators.

All of these capabilities were demonstrated successfully, although, as noted previously, failure detection and feedback messages were limited in scope. It was also observed that operator-system dialogs, which were exchanged via the operator console keyboard and printer, are time consuming, particularly if the operator makes a data entry error. Since there is only one level of menu-driven procedures, an experienced operator is limited in how much improvement is possible in performing these interactions. There were no serious failures of the system controller. The original disk drives were subject to numerous "crashes," but these were replaced at the midpoint of the demonstration with highly reliable Winchester-type drives.

PRC chose to write all of the system software (firmware) in the Z-80 assembly language, since the ImageNet bus was designed around the Z-80 microprocessor. The programs were stored in programmable read-only memory (PROM). Exclusive use of assembly language programs stored in hardware memories was indirectly responsible for the limited variety of operator menus. Changes were relatively difficult to implement, and debugging of major changes was particularly difficult and time consuming. Minor improvements were usually not pursued until there were enough to justify reprogramming new PROMs. Many enhancements identified during the demonstration were not pursued, although major bugs were corrected and a couple of enhancements, such as changing the order of the audit trail, were implemented.

Operator Console

The operator console is the controlling terminal for all MITS operations. Its functions include the following:

Display system status and sound alarms to announce system and subsystem failures.

Input operator-to-system commands.

Input request and fiche identification data.

Print audit reports.

Again, all of these functions were demonstrated successfully. The use of a teletypewriter console was not as convenient as a CRT-type terminal and line printer combination. The teletypewriter printing element could not keep up with the typing speeds of the operators (partially because of the slow data input/output speed of the system controller). In addition, excessive quantities of paper were used for routine operations, such as data entry, and for failure determination and correction activities. Excessive amounts of time were required to print the audit reports. The alternative, a CRT display and

a line printer, could help solve both the typing and printing speed limitations and the paper waste problem. Paper usage could be limited to satisfying specific requirements, such as the audit reports, on a demand basis. Most operator-system interactions would be displayed only on the CRT screen. Increasing the controller I/O data rates would also improve the typing and printing speeds.

Microfiche Scanner

The microfiche scanner performs a particularly complex set of functions, including the following:

Transport the input microfiche from the scanner input hopper to the scanning position.

Scan identifying labels in the header region of the fiche and convey this information to the recorder.

Position the microfiche and/or scanner for scanning of the desired microfiche.

Illuminate and scan the microfiche.

Detect blank image locations and advance to the next occupied image location for scanning.

Output the microfiche after all the microimages have been scanned.

Except for the scanning of header identification labels, all these functions were performed successfully by the scanner. Header identification is achieved by keystroking the appropriate data into the operator console.

Although the other functions were performed by the scanner, there were a couple of problem areas. The blank-image-detection routine, which was performed during the prescan cycle for each image, was reliable for full-page documents, but half- or quarter-page documents were occasionally missed. The image-center routine also performed during the prescan was not very effective. Since the Navy's microimages are individually attached to the master fiche by the "strip up" method, there can be variation in their positions relative to one another and to the fiche borders. At the 24X reduction, variations of only 0.040 inch (40 mils) are manifested as full-scale displacements of 1 inch.

To counter these variations, PRC developed an image data correlation technique that makes use of the data from the prescan to determine the upper and left-hand margins. This position coordinate is then used to reposition the platen for the actual scan. The correlation algorithm is highly sensitive to the information content in the upper left corner of each image. This causes variations in the image position accuracy. The consequence is frequent truncation of the margins (and occasionally the text) in the output microimages, usually near the top or bottom of the documents. Because of the image content dependence, these variations in output occur even if the input images are all uniformly positioned. One troublesome situation occurs when the tops of the first row of images (row A) are overlapped by the header stripe on the diazo

film. Although this occurred on only a couple of occasions, the displacements were severe because the prescan could not identify any top margins.

The fiche transport operated well during most of the demonstration, but a couple of problems were observed. Fiche that curl away from their emulsion side (having reverse curl) or those with excessive curl would not fit between the glass plates of the scanning platen. Film curl was found to depend on the brand of diazo film, storage conditions, and proximity to the end of the fiche roll, where the film is more tightly spooled. Most of the loading jams were attributable to a single roll of defective (excessive and reverse curl) diazo film. Occasionally, the transport had difficulty extracting a fiche from the platen, whereupon a jam would occur at the platen-transport interface. Both kinds of transport problem were corrected during the demonstration period through precise alignment of the transport and platen, replacement of a fiche restraining solenoid, addition of a retry feature to the fiche loading software, and careful attention to the use of nondefective diazo film in the duplicators.

High-Bandwidth Communications Link

The communications link is designed to convey both image data and system status and command data. Its specific functions are as follows:

Transmit document image data, header data, and command data to the facsimile microfiche recorder.

Transmit recorder status data to the system controller.

The Farinon digital radio performed both functions at the required 1.544-Mbps data rate. There was an observed tendency, however, for the carrier frequencies to drift, causing degradation of the signal and occasional interruptions. Retransmission of image data was required for most records during the last 2 months of the demonstration period. Record transmission times increased because the system controller was programmed to keep retransmitting blocks of data subjected to interruptions until the entire image is successfully transmitted. It was not until near the end of the demonstration that frequency drift was isolated as the problem. When the frequency is properly adjusted, radio performance is reliable and within specifications.

Facsimile Microfiche Recorder

The facsimile recorder is the most complex and most fragile system component. Its functions include the following:

Receive image data and reproduce cut and processed facsimile microfiche.

Produce either image-packed (blanks removed) or true facsimile output upon operator command.

Produce identifying labels on the header area of output microfiche to identify individual's name and SSN.

Convey recorder status to system controller.

Because of its complexity and the relative severity of the operating environment (eg marginally adequate air conditioning), the recorder was a temperamental component. It performed its required functions with the exception that some kinds of failures were not communicated back to the controller and therefore were not made known to the system operators. The operators reported disliking the heat and noise generated by the recorder. Heat was produced by the recorder electronics and power equipment and by the fiche dryer. Exhaust heat from the dryer was directed into the room through the output hopper. Most of the noise was due to the recorder's vacuum pump and the processing chemistry pumps, although there were contributions from cooling fans associated with the electronics and from other mechanical components.

As discussed earlier, poor output image quality was regularly observed. Usually this was due to improper development in the processor (as distinct from the effects of digitization discussed earlier). It was discovered that fogged or very low contrast output was produced if the developer had prematurely oxidized. Oxidation apparently occurs if the chemistry packs are exposed to prolonged low temperatures, such as during wintertime shipments by truck or during storage in an unheated room. At ambient office temperatures, the developer must be replaced at least once a week, regardless of the number of fiche processed. Daily monitoring of the chemistry performance became a standard operator procedure. Another film problem was incomplete drying of the fiche before their ejection to the output hopper. Although several drying agents were tried, this problem was never completely solved. In consequence, fiche left in a stack in the output hopper were frequently bonded together and could not be separated.

Several observed mechanical and electrical failures could have been eliminated or reduced with some design modifications. Failures occurred in the x-y positioning motors, the fiche cutter mechanism, the film rollers in the processing tanks, and the processing chemistry pumps. Since frequent cleaning and corrective maintenance were required, the remote-site operators became adept at troubleshooting and repair.

PERSONNEL STAFFING AND PERFORMANCE

A primary function of the demonstration was to evaluate the skill levels required of the system operators. Of special interest was the suitability of the operating procedures and protocols as designed and implemented, such as the procedures and interactive dialogs required for data entry, for microfiche loading, and for general operations of the scanning and recording hardware and software.

To evaluate operator performance, periodic personal interviews were conducted by NPRDC. Operators and their supervisors were interviewed. Operator annotations in the logs were also reviewed. The interview forms and the analysis methodology are presented in detail in the NPRDC summary report (ref 9).

Central-Site Operators

Highly skilled operators were not required at the central site, since many of their duties involved system-directed activities. All the operators employed during the demonstration had clerk-typist backgrounds, and most had some familiarity with computer terminals. Their enthusiasm about new job duties and personal interest in being involved in testing a new and exotic system were important factors in achieving a high quality of performance during the demonstration.

The operators reported that they were comfortable with the procedures and found the system "easy" to operate. They also indicated that they were satisfied with the scope and quality of the training. The training program, an important consideration from the project's inception, therefore seems to have been a success. The operators did not report feeling frustrated or disenchanted by the frequency of system failures. Their positive attitude probably was due to the congeniality and responsiveness of the maintenance personnel and to the fact that the only consequence of downtime was a return to their regular duties. Pressure to transmit a particular number of records per day was nonexistent, activity was small, and there were no backlogs. They were able to pursue their regular positions, and they treated MITS support as a part-time job.

Responsive, qualified, on-site maintenance personnel were essential team members, since the prototype experienced such a variety of failures. The maintenance personnel were regularly involved in activities ranging from helping debug assembly level computer programs to replacing burned-out pump motors and corroded film rollers. A great deal of their time was dedicated to fault diagnosis. Such a diversity of tasks required background in digital electronics, electromechanical device design, programming, and film processing. Since a production system would be expected to be more refined and reliable than the demonstration prototype, extensive on-site capabilities in these areas probably would not be as critical for an operational installation. Nevertheless, access to these resources will always be necessary. A more complete analysis and extracts of the operator and maintenance personnel interviews are provided in reference 9.

Remote-Site Operators

Remote-site operators' responses to the interviews were similar to those of the central-site operators, as described above. Rather than being clerk-typists, remote site personnel included a chief warrant officer/personnel specialist, a Navy civilian employee with a technical background, and a Navy civilian administrative assistant. Because the requests were made by telephone, rather than from a remote terminal, typing skills and ability to respond to menu-driven routines were not evaluated. Most remote-site duties involved direct interface with active-duty Navy personnel, maintaining the remote-site activity log, documenting disposition of the records, and performing preventive maintenance tasks. The technical background of one of the operators and the problem-solving capabilities of all three were instrumental in keeping the recorder running and in assisting the maintenance personnel in failure diagnosis. They were frequently able to perform corrective tasks from telephoned instructions. Their ability to interact cordially with the requesting users and their familiarity with personnel matters were useful in

maintaining a significant level of user interest in the MITS product and in assuring adequate request activity for the demonstration.

ACCEPTABILITY TO NAVAL PERSONNEL

User perceptions of the value and convenience of the MITS service and the quality of the product are important measures of user acceptance of the system. Because interviews could not be conducted conveniently on a regular basis, a short questionnaire was distributed to each requestor who received a facsimile record. Each recipient was asked to fill it in and mail it directly to NPRDC for analysis.

The questionnaires were given to MITS requestors during May and June of the demonstration period. There were 51 respondents, of which 14 were officers and 37 were enlisted personnel. Areas of special interest to the analysts were perceptions of image quality, length of delivery time, and overall evaluation of the MITS service. A complete summary of responses is provided in appendix C.

Many of the requestors had not viewed their microfiche file in any form prior to receiving the MITS facsimile copy. Their reaction to image quality was more favorable than that reported by the evaluation panels described earlier. Nearly half of the respondents (47 percent) judged the image quality to be good or excellent, and 22 percent judged it to be less than satisfactory. Although most of the respondents indicated that they had to wait more than 30 minutes for their records (consistent with the 46-minute average turnaround time), over half reported the MITS service was faster than expected and 76 percent felt the service was good or excellent. In their analysis of the questionnaires, NPRDC observed that

1. Overall, MITS was evaluated as a highly satisfactory delivery system.
2. The majority of personnel record requestors assessed the image quality as adequate or better.
3. The majority of requestors gave MITS an overall evaluation of good or excellent.
4. Respondents who had previously requested their records rated MITS as faster, found it easier to request a record, and preferred it to the previous service (contacting NMPC in person or by mail).

SOME LESSONS LEARNED

Several findings from the MITS evaluation seem to have broad applicability to facsimile system development efforts. These "lessons learned" relate to output image quality, operating procedures, system reliability, testing, and maintenance.

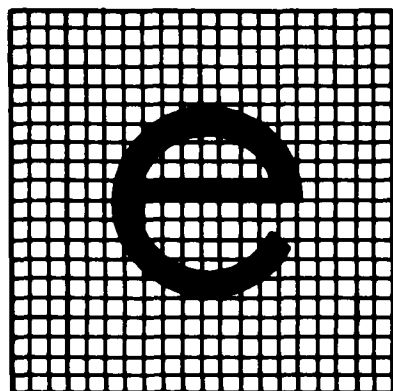
GRAY LEVEL VS BITONAL SCANNING

The image quality effects noted earlier in this report, such as character filling and edge breakup, seem to be attributable to inherent limitations of bitonal processing. When the scanning aperture passes across a character edge, a continuous variation in the analog video signal is produced. During digitization of this signal, the continuous variation is subdivided into discrete levels. The video processor then makes a bitonal conversion by establishing a threshold level and comparing the discrete values to that threshold. For MITS, the threshold levels were allowed to vary in accordance with the average signal levels, through a process known as adaptive thresholding. If the aperture partially overlaps a character edge, it is possible for the resulting pixel to be improperly interpreted as background. When this occurs, small pieces of character edges and holes appear to be broken or have filled-in features. The severity of this effect depends on the aperture size relative to the character size (height, width, boldness of font) and the responsiveness of the thresholding algorithm. The effects of threshold response are illustrated in figure 28.

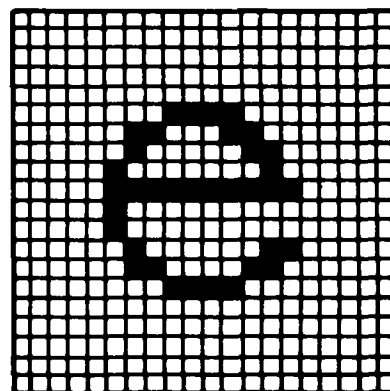
Demonstrated improvements in bitonal processing performance have used "nearest neighbor" convolution schemes, higher resolution scanning, or multiple gray-level scanning. The first two techniques hold promise for improving the edge breakup problem as long as the input documents are of high contrast. For low-contrast input such as carbon-copy print or faded documents, only gray-level scanning seems to be capable of reproducing the information. Initial investigations at NOSC indicate that eight levels (3 bits) are adequate for most low-contrast documents. Convolution techniques, also referred to as edge enhancers, have been observed to sharpen lines and character edges through their ability to weight pixel values on the basis of values of the nearest neighboring pixels. Because of insufficient dynamic ranges in the thresholders, these techniques have not demonstrated an ability to detect faint characters. Similarly, scanning at a higher resolution, such as 300 pixels per inch, has been observed to sharpen character edges but has not been able to improve detection of faint characters.

All the bitonal schemes tend to emphasize cosmetic flaws such as scratches or dust, whereas gray-level scanning tends to reproduce the overall document appearance more accurately. Note that the gray-level approach introduces a threefold or greater increase in the amount of image data that must be processed, stored, and transmitted. It also requires specialized output components (such as COM recorders, image displays, or hardcopy printers) that have gray-level capability.

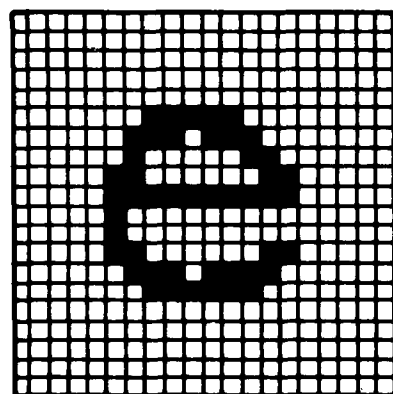
The ultimate choice of processing technique will depend on the characteristics of the document collection. Poor-quality low-contrast documents will usually be present in personnel records collections, such as the Navy's MPRS.



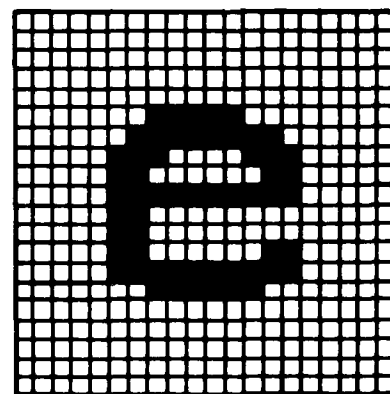
ANALOG



"HIGH" THRESHOLD



"MEDIUM" THRESHOLD



"LOW" THRESHOLD

Figure 28. Effects of bitonal thresholding.

Therefore, some form of gray-scale capability will be required to satisfy the users' needs for good-quality legible output. For collections characterized by uniformly high quality microfilm images of high contrast documents, the use of either a convolution processor or higher resolution scanning seems to be a more appropriate choice for improving output image quality.

DATA ENTRY BY BAR CODE SCANNING

The MITS operating procedures could have been improved by implementing bar code scanning at the operator console or the scanner. Much of the central-site operator's workload could be reduced if the keystroking required to identify the fiche were eliminated. Bar code scanning would also help reduce data entry errors and thereby speed the loading process. If bar code verification were integrated into the scanner, the central-site operators' tasks could be simplified to sorting fiche, making quality assurance checks prior to loading batches of fiche, monitoring malfunction alarms during transmission, disposing of duplicates after scanning is complete, and periodic printing of audit reports. This scenario could be further improved if direct communication between the MPRS controller and the MITS controller were provided, so that the operator could perform more of a confirmation role than a data entry role. The controllers would then coordinate most of the requesting, loading, and transmission activities.

RELIABILITY

Although the reliability analysis performed for the demonstration was a somewhat simplistic assessment, it did indicate serious shortcomings in the prototype design. The varieties of failure and the lengths of time required to diagnose the problems and effect repairs were clearly unacceptable for any kind of production environment. The current MITS configuration must therefore be considered as a prototype for test and evaluation purposes rather than as an operational system. The low reliability should be recognized as representative of a particular prototype system, not as behavior characteristic of microfacsimile as a technology.

Many of the interruptions during the demonstration were due to mechanical breakage or electronic component failure. These should be readily correctable through relatively minor redesign or modification once the specific problems are identified. On the other hand, the software problems will continue to be difficult to solve as long as all programs are written in assembly language and stored as firmware in PROM memory. The use of a higher order language, such as "C" or Pascal, coupled with magnetic storage of the programs would significantly improve the system programmer's abilities to tailor the software to evolving MITS requirements and to correct bugs more efficiently as they are discovered.

TESTING AND MAINTENANCE

In retrospect, the MITS team should have been more diligent in thoroughly exercising the system to reveal as many failure modes as possible. This is understandably not an easy undertaking, given the complexity of the system and the normal pressures to get contracted development work completed within budget and schedule. It is essential that the designers establish comprehensive

and detailed maintenance procedures and prepare an equally thorough maintenance manual prior to an operational installation. Provision should also be made to include a suite of diagnostic instruments as part of the system. It was quite fortunate that the system designers and the maintenance personnel were dedicated to and creative in diagnosing the causes of failures and improving solutions. This commitment was instrumental in keeping MITS operating during the demonstration. For implementing a successful production system, however, better advance planning and testing and proven, documented maintenance procedures are essential.

SUMMARY OF FINDINGS

This section summarizes the results of the MITS demonstration. It covers system performance, problem areas, and overall findings.

SYSTEM PERFORMANCE

The MITS Demonstration was successfully conducted between NMPC and PSD, Anacostia, from mid-December 1981 to mid-June 1982.

More than 1000 microfiche, representing nearly 300 complete records, were transmitted in an average turnaround time of 45 minutes per record. These records contained a total of 22 500 document images.

Average transmission time was under 8 seconds per document, 13 minutes per record (80 documents, 4 fiche).

Facsimile legibility was judged to be acceptable for most of the transmitted documents, but 26% of the output records were considered to be unreadable.

Mean time between failures (MTBF) was approximately 5 hours, and mean time to repair (MTTR) was approximately 4.5 hours.

PROBLEM AREAS

Frequent failures and extended diagnosis and repair times limited system availability to 50 percent of normal working hours.

The following list includes the most significant system and component deficiencies:

- Document legibility (26 percent unreadable).

- Physical condition of output fiche (sticking,

- Fiche retrieval (individual retrievals too time consuming).

- Data entry procedures (excessive keystroking).

- Operator console (input/output speeds too slow, wastes paper).

- System software (difficult to debug, enhance).

- Scanning speed (insufficient throughput).

- Image detection (too slow, truncates images).

- Image centering (too slow, truncates images).

- Digital radio frequency drift (transmission errors, delays).

Recorder reliability.

Oxidation of film-processing chemistry.

Failure diagnostics (not comprehensive, not explicit).

Maintenance (lack of standard procedures, no maintenance manual).

In addition to having a low reliability due to a variety of failure modes, the output recorder was not well suited to an office environment, primarily because of heat and noise generation and preventive maintenance requirements.

Other minor deficiencies include the following:

Inability to transmit individual non-record fiche.

Lack of a program to automatically tally audit reports.

Lack of an alarm to signify completion of an output record.

Printer/terminal slowness, which limited the speed of request data entry and audit report printout.

Fault diagnosis and maintenance procedures were not thoroughly documented in a maintenance manual.

OVERALL FINDINGS

Interviews of MITS/NMPC operators (contractor) and MITS/PSD operators (military and civilian) validated the effectiveness of system procedures and operator training.

Questionnaires returned by record recipients indicated (1) positive responses by Navy personnel to receiving their own records and (2) general acceptance of facsimile record quality.

Operator personnel indicated a high level of satisfaction with the responsiveness of maintenance personnel but some frustration with the frequency of system failures.

In spite of potential for improvements in image processing and system reliability, the demonstration configuration has inherent speed limitations that seem to preclude its use in a high-volume production environment.

RECOMMENDATIONS

NMPC

Continue to distribute microfiche personnel records to field activities and to individuals via the US Mail, employing batch handling between major Navy facilities when practical.

Respond to urgent requests by using "Express Mail" as appropriate.

Because of inherent performance limitations of the demonstration configuration, do not exercise an option to buy the prototype MITS for operational purposes.

Monitor other funded efforts at NOSC aimed at improving document legibility and image data transmission speed.

Monitor planned implementations of wideband telecommunications capability between major Navy facilities.

Evaluate applicability of partial record (eg selected-document) transmission and alternative output formats (eg video displays) for satisfying urgent record access requirements.

Update record transmission projections for the 1983-1990 period.

Continue to include record transmission considerations in future upgrades of the Military Personnel Record System (MPRS), particularly (1) bar code identification of individual fiche, (2) remote request procedures, and (3) storage, retrieval, and duplication procedures.

Continue to monitor vendor development efforts toward improving document scanning speed and legibility, high-speed image data transmission, and dry-process recording.

Monitor the success and cost effectiveness of similar systems being developed to distribute microfilm document images to high-resolution video terminals.

NOSC

Encourage standardization of image data transmission interfaces so that new devices from a variety of manufacturers can be readily integrated into future document distribution systems. The objective is to avoid development or procurement of one-of-a-kind systems, which are difficult and expensive to maintain because production quantity economies and reliability cannot be realized.

Evaluate alternative design approaches for correcting deficiencies revealed by the demonstration.

Continue to monitor performance improvements and cost reductions in applicable technologies.

On a regular basis, informally advise NMPC on the commercial development status of components and systems.

Assist NMPC in procuring an operational MITS when such an installation is justified by anticipated improvements in the performance and cost effectiveness of commercially available components.

FUTURE PLANS

The Microfiche Image Transmission System has successfully demonstrated the technical feasibility of microfacsimile as a means of distributing Navy military personnel records. Although feasibility has been shown, a number of improvements in hardware, software, and procedures are necessary to ensure successful application of the MITS technology to truly operational situations. These applications will require higher throughput, better output quality, and much higher system reliability. Current plans call for NOSC to investigate alternative solutions to the most critical system deficiencies during FY83. Particular attention will be directed to the following:

- Design of a stack loading mechanism for a scanner.

- Design of a bar code label reader for a scanner.

- Evaluation of multi-gray-level scanning for improving output image quality.

- Evaluation of multi-gray-level recording.

- Design of a data compressor for multi-gray-level data.

- Methods for improving image detection and positioning.

- Enhanced system software that uses high-order language.

- Faster, more efficient, more user-friendly operating procedures.

- Improved system reliability and maintainability.

The results of these investigations will be incorporated in a second-generation design and specification, with which NMPC will be able to procure a production system. Current plans call for an FY85 procurement of a system to operate between NMPC and a Navy facility in the San Diego area. Subsequent expansion of the system to include other major Navy facilities, such as Norfolk or Pearl Harbor, will be predicated on the success of the initial link. Such procurements will be made only after a rigorous cost benefit analysis is completed for each selected application.

REFERENCES

1. NOSC technical note NUC TN 1561, Microfiche Image Transmission System (MITS) Feasibility Study for the Bureau of Naval Personnel, by B Saltzer, C Morrin, D Griffin, and D Solarek, June 1976. NOSC TNs are informal documents intended chiefly for internal use.
2. NOSC technical publication NUC TP 519, The Bureau of Naval Personnel's Microfiche Image Transmission System (MITS): A State-of-the-Art Microfacsimile System, by D Endicott, D Solarek, and K Drake, December 1976.
3. NOSC TN 711, Application Selection and Preliminary Design for the Microfiche Image Transmission System (MITS) Demonstration, by D Endicott and B Saltzer, September 1979.
4. NOSC Code 941 Statement of Work and Technical Specification for the Microfiche Image Transmission System (MITS) Demonstration, December 1979.
5. Navy Contract N00123-80-C-0714, 30 September 1980. Cognizant NOSC Code: 941.
6. PRC Image Data Systems Company, Microfiche Image Transmission System (MITS) Design Review Description Document, Revision 1.0, Navy Contract N00123-80-C-0714, CDRL A002, February 1981.
7. NOSC technical note NUC TN 1731, Legibility and Resolution Criteria for the Bureau of Naval Personnel's Microfiche Image Transmission System (MITS), by A Gordon, September 1976.
8. PRC Image Data Systems Company, Microfiche Image Transmission System (MITS) Final Acceptance Test Plan, Navy Contract N00123-80-C-0714, CDRL A004, 3 June 1981.
9. Navy Personnel Research and Development Center Special Report SR 83-40, A Multifaceted Approach in Assessing the MITS Demonstration Project, by J Sheposh and V Hulton, May 1983.

APPENDIX A: SYSTEM ACTIVITY SUMMARY

Period	Records (number)	Fiche (number)	Images (number)	Scan Time (min:s)	Time/Image (s)
12/14-12/24	25	77	NA	NA	NA
12/28-1/12	25	107	NA	NA	NA
1/12-1/22	26	127	NA	NA	NA
1/22-2/3	28	116	NA	NA	NA
2/3-3/19	14	49	NA	NA	NA
3/22-4/5	24	71	NA	NA	NA
4/5-4/14	31	87	NA	NA	NA
4/19-4/23	36	117	2454	329:6	8.0
4/26-4/30	37	127	2379	321:56	8.1
5/3-5/7	14	52	1356	176:38	7.8
5/10-5/14	11	49	1404	169:31	7.2
5/17-5/21	1	2	24	4:3	10.1
5/24-5/28	0	—	—	—	—
6/1-6/4	7	25	637	75:27	7.1
6/7-6/10	3	9	243	33:48	8.3
<hr/>					
12/14-4/14*	173	634	(14 000)	NA	NA
4/19-6/10	109	381	8497	1110:29	7.8

*Audit reports for the period 14 December 1981 to 14 April 1982 were inadvertently erased by MITS maintenance personnel. Consequently, these activity figures are taken from the remote-site log. No measures of scan time are available for this period. The total response times were recorded in the remote-site log. The average value for these times is 46.4 minutes. The image count is an estimate based on probable similarity to the fiche transmitted between 19 April and 10 June.

APPENDIX B: SYSTEM MAINTENANCE SUMMARY

Date	Failure Description	Number	Repair Time (h:m)
3/22	Film jam, cutter failed	1	2:0
3/23	Lead screw defective (recorder camera)	1	24:0
3/26	Broken gear in recorder drive	1	5:0
3/30	Recorder film roller jam (gear misalignment)	1	23:0
4/6	Recorder pump failure	1	1:45
4/7	Recorder film puller motor	1	1:40
4/8	SCP time-out (recorder x-y failure)	1	0:20
4/9	Recorder x-y drive	1	6:0
4/15	Radio link down	1	6:20
4/16	Call errors on disk	3	3 X 0:5
4/20	CRC error at scanner	1	0:10
	Recorder loss of vacuum	2	2 X 0:10
4/21	SCP time-out (radio drift)	1	2:0
<hr/>			
3/22-4/21	Total Activity	16	72:50

Note: Only the period of 3/22/82 to 4/21/82, a high-activity period, was selected for the maintenance analysis. System behavior during these 19 operating days was representative of that following completion of the Winchester disk upgrade.

APPENDIX C: SUMMARY OF USER ACCEPTANCE RESPONSES

Exhibit C1 is extracted from the NPRDC analysis of user and operator reactions to MITS (ref 9). This table summarizes the responses to the questionnaire given to each requestor who received records.

	Total	First Request	Previous Request	Packed	Unpacked	Officers	Enlisted
1. How did you find out that you could request a record from PSD?							
a. I saw the posted announcement.	2(4)	2(5)	0	1(4)	1(6)	1(7)	1(3)
b. I heard by word of mouth...	35(69)	26(67)	9(75)	21(78)	10(56)	6(43)	29(78)
c. Other	14(27)	11(28)	3(25)	5(19)	7(39)	7(50)	7(19)
2. Why did you want a copy?*							
a. General reference	18(31)	16(36)	2(14)	8(29)	8(35)	1(7)	17(40)
b. To make sure the record is complete, accurate, up-to-date.	28(48)	21(48)	7(50)	13(46)	11(48)	10(67)	18(42)
c. To review a particular document	9(16)	6(14)	3(21)	5(18)	3(13)	2(13)	7(16)
d. Other	3(5)	1(2)	2(14)	2(7)	1(4)	2(13)	1(2)
3. Where did you review your record?*							
a. At the PSD facility	40(77)	32(80)	8(67)	24(89)	13(68)	6(43)	34(89)
b. At my office	12(23)	8(10)	4(33)	3(11)	6(32)	8(57)	4(11)
c. At home	0	0	0	0	0	0	0
d. Other	0	0	0	0	0	0	0
4. How did you read the microfiche?							
a. A desktop reader	47(92)	37(95)	10(83)	25(93)	16(89)	14(100)	33(89)
b. A handheld reader	1(2)	1(3)	0	0	1(6)	0	1(3)
c. Other	3(6)	1(3)	2(17)	2(7)	1(6)	0	3(8)
* Multiple responses							

Exhibit C1. Frequencies and percentages for personnel record questionnaire items.

	Total	First Request	Previous Request	Packed	Unpacked	Officers	Enlisted
5. Approximately how many documents did you attempt to read?							
a. Less than five	9(18)	6(15)	3(25)	8(30)	1(6)	3(21)	6(16)
b. Between five and ten	13(25)	12(31)	1(8)	5(19)	8(44)	11(79)	2(5)
c. More than ten	29(57)	21(54)	8(67)	14(52)	9(50)	0	29(78)
6. How well were you able to locate the specific documents which interested you?							
a. 5 Experienced great difficulty	3(6)	0	3(25)	2(7)	1(6)	0	3(8)
b. 4	2(4)	2(5)	0	0	1(6)	1(7)	1(3)
c. 3 Experienced some difficulty	11(22)	8(21)	3(25)	6(22)	4(22)	2(14)	9(24)
d. 2	9(18)	7(18)	2(17)	5(19)	3(17)	4(29)	5(14)
e. 1 Experienced no difficulty	26(51)	22(56)	4(33)	14(52)	9(50)	7(50)	19(51)
7. How would you rate the overall image quality of the record?							
a. 5 Excellent	11(22)	8(21)	3(25)	6(22)	3(17)	5(36)	6(16)
b. 4	13(25)	10(26)	3(25)	8(30)	3(17)	5(36)	8(22)
c. 3 Okay	15(29)	13(33)	2(17)	6(22)	7(39)	1(7)	14(38)
d. 2	9(18)	7(18)	2(17)	5(19)	4(22)	3(21)	6(16)
e. 1 Unreadable	2(4)	0	2(17)	1(4)	1(6)	0	2(5)
f. No response	1(2)	1(3)	0	1(4)	0	0	1(3)
8. How long after your request did you receive your record?							
a. Less than 15 minutes	1(2)	0	1(8)	0	1(6)	1(7)	0
b. Between 15 and 30 minutes	9(18)	8(21)	1(8)	5(19)	3(17)	0	9(24)
c. Between 30 and 60 minutes	12(24)	10(26)	2(17)	6(22)	3(17)	2(14)	10(27)
d. More than 60 minutes	25(49)	18(46)	7(58)	15(56)	8(44)	9(64)	16(43)
e. Other	4(8)	3(8)	1(8)	1(4)	3(17)	2(14)	2(5)

Exhibit C1. (cont)

	Total	First Request	Previous Request	Packed	Unpacked	Officers	Enlisted
9. The turnaround time was							
a. Much faster than you expected	18(35)	12(31)	6(50)	9(33)	6(33)	4(29)	14(38)
b. Faster than you expected	11(22)	10(26)	1(8)	5(19)	4(22)	5(36)	6(16)
c. About what you expected	13(25)	11(28)	2(17)	10(37)	3(17)	3(21)	10(27)
d. Slower than you expected	2(4)	0	2(17)	1(4)	1(6)	0	2(5)
e. Much slower than you expected	2(4)	1(3)	1(8)	1(4)	1(6)	2(14)	0
f. Did not know what to expect	5(10)	5(13)	0	1(4)	3(17)	0	5(14)
10. What is your overall evaluation of this procedure for obtaining your record?							
a. 5 Excellent	24(47)	18(46)	6(50)	10(37)	10(56)	9(64)	15(41)
b. 4	15(29)	14(36)	1(8)	9(33)	4(22)	2(14)	13(35)
c. 3 Okay	9(18)	7(18)	2(17)	7(26)	2(11)	2(14)	7(19)
d. 2	0	0	0	0	0	0	0
e. 1 Poor	3(6)	0	3(25)	1(4)	2(11)	1(7)	2(5)
11. Had you viewed microfiche of any kind before this request?							
a. Frequently	25(49)	21(54)	4(33)	13(48)	7(39)	8(57)	17(46)
b. Occasionally	9(18)	6(15)	3(25)	6(22)	3(17)	2(14)	7(19)
c. Once or twice	11(22)	6(15)	5(42)	4(15)	6(33)	4(29)	7(19)
d. Never	6(12)	6(15)	0	4(15)	2(11)	0	6(16)
12. Had you previously requested your microfiche record?							
a. No	39(76)	39(100)	0	21(78)	13(72)	8(57)	31(84)
b. Yes	12(24)	0	12(100)	6(22)	5(28)	6(43)	6(16)

Exhibit C1. (cont)

	Total	First Request	Previous Request	Packed	Unpacked	Officers	Enlisted
13. If your answer to question 12 is <u>Yes</u> , how would you compare the present and previous service on the following factors?							
13a. The present service is much faster than the previous service.							
a. 5 Strongly agree			7(58)	4(67)	2(40)	4(67)	3(50)
b. 4			1(8)	0	1(20)	0	1(17)
c. 3 Neutral			1(8)	0	1(20)	1(17)	0
d. 2			1(8)	1(17)	0	1(17)	0
e. 1 Strongly disagree			2(17)	1(17)	1(20)	0	2(33)
13b. It is much more difficult to locate documents with the present service.							
a. 5 Strongly agree			0	0	0	0	0
b. 4			1(8)	1(17)	0	0	1(17)
c. 3 Neutral			1(8)	1(17)	0	1(17)	0
d. 2			1(8)	1(17)	0	1(17)	0
e. 1 Strongly disagree			8(67)	3(50)	4(80)	4(67)	4(67)
f. No response			1(8)	0	1(20)	0	1(17)
13c. The image quality of the present service is much better than the image quality of the previous service.							
a. 5 Strongly agree			3(25)	1(17)	2(40)	1(17)	2(33)
b. 4			1(8)	1(17)	0	1(17)	0
c. 3 Neutral			4(33)	1(17)	2(40)	2(33)	2(33)
d. 2			2(17)	2(33)	0	1(17)	1(17)
e. 1 Strongly disagree			2(17)	1(17)	1(20)	1(17)	1(17)

Exhibit Cl. (cont)

Total	First Request	Previous Request	Packed	Unpacked	Officers	Enlisted
13d. It is much more difficult to request my record with the present service than with the previous service.						
a. 5 Strongly agree		2(17)	1(17)	1(20)	1(17)	1(17)
b. 4		0	0	0	0	0
c. 3 Neutral		0	0	0	0	0
d. 2		4(33)	3(50)	1(20)	2(33)	2(33)
e. 1 Strongly disagree		6(50)	2(33)	3(60)	3(50)	3(50)
13e. I prefer the present service to the previous service.						
a. 5 Strongly agree		6(50)	2(33)	3(60)	3(50)	3(50)
b. 4		3(25)	2(33)	1(20)	1(17)	2(33)
c. 3 Neutral		0	0	0	0	0
d. 2		1(8)	1(17)	0	1(17)	0
e. 1 Strongly disagree		2(17)	1(17)	1(20)	1(17)	1(17)

Exhibit C1. (cont)

END

FILMED

12-83

DTIC